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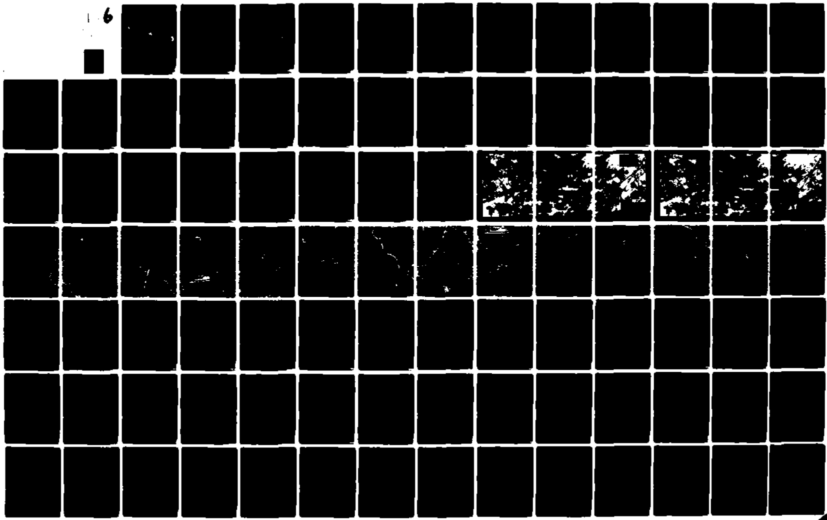

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INTERN EXPERIENCE WITH

TURNER COLLIE & BRADEN INC.

VOLUME I

An Internship Report

by

Dennis [illegible] Cooper

Approved as to style and content by:

(Chairman of Committee)

A

(Head of Department)

(Member) (Member)

(Member) (Member)

(Member) (Member)

August 1979

ABSTRACT

[illegible] Experience with Turner Collie & Braden Inc. (August 1979)

Dennis Richard Topper, B.S.[illegible],

[illegible] States Air Force Academy

M.S. [illegible] University of Oklahoma

Chairman of Advisory Committee: Dr. Donald McDonald

[illegible] report [illegible] my intern experience with Turner [illegible] & Braden In[illegible] during the period from August [illegible], 197[illegible] [illegible] 1979. The purpose of this paper is to [illegible] that my efforts with Turner [illegible] & Braden [illegible] internship requirement [illegible] at Texas A&M University. [illegible] the internship [illegible] [illegible] prepared an Airport Master [illegible] western [illegible], Texas. [illegible] experience [illegible] Master Plan [illegible] sewerage [illegible] Area of Houston, Texas

3. Exposure to the day-to-day managerial techniques utilized by a consulting engineering firm. I assisted the technical chiefs of the firm in the quality control review of a proposed expansion of the Sugarland, Texas Wastewater Treatment Plant and the Kerrville Water Treatment Plant. Unfortunately, I was unable to attend any upper level management meetings within the company.
4. Expanded professional development as an Air Force Civil Engineering Officer. I definitely developed an appreciation for the consulting engineer's point of view in his relationships with governmental agencies.
5. Increased insight into the management of a large number of engineering personnel.

My time with Turner Collie & Braden Inc. was my most satisfying educational experience. The internship certainly enhanced my development as an Air Force Civil Engineering Officer.

DEDICATION

TO MY PARENTS

ACKNOWLEDGMENTS

I wish to gratefully acknowledge the following people for their assistance in the completion of my internship:

Dr. Donald McDonald, P. E., Professor of Civil Engineering and Chairman of my Graduate Advisory Committee;

Dr. Neil E. Bishop, P. E., the Internship Supervisor and Chief Environmental Engineer for Turner Collie & Braden Inc.;

Mr. William G. Griffin, P. E., Chief, Airport Planning Team for Turner Collie & Braden Inc.;

Mr. William J. Moore, Chief, Environmental Planning Team for Turner Collie & Braden Inc.

Special thanks is due also to Mr. Lawrence L. Rabalais, Senior Engineering Technician with Turner Collie & Braden Inc., for his efforts in preparing the graphics for the Northside Sanitary Sewerage System Master Plan.

My sincere appreciation also goes to the primary typist for this report, Mrs. Louise Feder, whose patience was limitless.

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INTRODUCTION

During the nine-month period from August [illegible], 1978 to May 25, 1979 I completed an internship with Turner Collie & Braden Inc. (TCB), a consulting engineering firm in Houston, Texas, in order to satisfy one of the requirements for the Doctor of Engineering (D. Engr.) degree from Texas A&M University. The intent of the internship is to enable the D. Engr. candidate to (1) make an identifiable contribution to the internship organization and (2) function in a nonacademic environment in order to receive exposure to problems not normally associated with traditional design or analysis but nonetheless requiring engineering expertise in their solution.

Description of the Internship Firm

Founded in 1946, Turner Collie & Braden Inc. is a consulting engineering firm with its main office located in Houston, Texas, and branch offices in Austin, Dallas, El Paso, and Port Arthur. The main thrust of TCB's practice has traditionally been in the area of civil and public works planning and design for municipalities, although the firm provides its services to other types of clients, including governmental agencies, corporate entities, and private developers. The company employs over 500 people and is organized as shown in Figure [illegible].

[illegible] & BRADEN INC

[illegible] — Chairman of the Board
[illegible] — President
[illegible] — Executive Vice President

[illegible] PERSONNEL SERVICES

DIVISION A	DIVISION B	DIVISION [illegible]	DIVISION [illegible]
[illegible] Senior Vice President	[illegible] Senior Vice President	[illegible] Senior Vice President	[illegible] Senior Vice President
Technical Departments	Project Teams	Project Teams	[illegible]
[illegible] Engr. Dept. [illegible] Engr. Dept. Environmental Engr. Dept. Mechanical Engr. Dept. Structural Engr. Dept. [illegible] Engr. Dept. [illegible] Engr. Dept.	[illegible] Project [illegible] [illegible] Project [illegible] [illegible] Project [illegible] [illegible] Project [illegible]	[illegible] Project [illegible] [illegible] Project [illegible] [illegible] Project [illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
Project Teams [illegible] Project [illegible] [illegible] Project [illegible] [illegible] Project [illegible]			Project Teams [illegible] Project [illegible]
[illegible] Environmental Laboratories	[illegible] Vice President [illegible]		[illegible]

[illegible] the [illegible] that [illegible]

[illegible] concept of the information was [illegible] with that of the [illegible]

Based on the September meeting, I decided to [illegible] The planning studies available [illegible] generally [illegible] high level [illegible] and [illegible] that [illegible] candidate is

[illegible]

of the [illegible] of the [illegible] review [illegible]

[illegible] results [illegible] prepared [illegible]

[illegible] Attendance at meetings [illegible]

management [illegible] in order [illegible] formulate [illegible]

for the successful operation of the company

[illegible]

[illegible] engineer's [illegible]

between [illegible] and the engineer[illegible]

[illegible]

[illegible] management [illegible]

[illegible] engineers [illegible]

NORTHWESTERN HARRIS COUNTY AIRPORT MASTER PLAN

In order to accomplish the first short-term objective of the internship, I was assigned to the Airport Planning Team within T/B. Mr. William G. Griffin, head of the team, was designated to be my immediate supervisor.

Nature of the Particular Assignment

In recent years the number of general aviation aircraft within Harris County has nearly doubled. In view of this growth, the requirement to better define the specific nature of the additional facilities needed to satisfy the projected aircraft demand in the northwest area of Harris County, and the potential need for public participation in the ownership of general aviation facilities in this area, the Harris County Commissioners' Court made application for and was offered a grant from the Federal Aviation Administration (FAA) for the purpose of developing an Airport Master Plan for a general aviation reliever airport located in the northwestern part of Harris County.

The Airport Master Plan was to be prepared in accordance with FAA Advisory Circular 150/5070-6 and "Instructions for Processing Airport Development Actions Effecting the Environment," FAA Order 5050.2B. The Master Plan study was to determine the need for a basic transport

airport located in northwestern Harris County to meet local aviation requirements.

> The study (was also to) determine the extent, type, and nature of airport development required to meet forecasted aviation demands in the northwest Harris County area within the short, median, and long-range time frames of 5, 10, and 20 years, respectively.
>
> Alternative airport sites (were to be) investigated with special consideration given to David Wayne Hooks Memorial Airport, located on Stuebner Airline Road near the intersection with Spring Cypress Road. The investigation of alternative sites (was to be) restricted generally to the area in northwest Harris County bounded by U.S. Highway 290 and Interstate Highway 45. (1)

The study was to be in two phases: Phase I, Site Selection, which culminated in an interim report is Appendix A of this internship report. This Phase involved the following tasks: Airport Demand and Activity Projections, Determination of Facility Requirements, Engineering Evaluation of David Wayne Hooks Memorial Airport, Site Evaluation and Selection, Environmental Review and Evaluation, Preparation of Interim Report. Supplementary comments on Phase I of the Airport Master Plan are incorporated below.

Phase II, the Economic Feasibility and Development Program, is included next in the body of this internship report.

Phase I: Demand and Activity Projections

The demand and activity projections were prepared based upon a forecast developed by TCB for all of Harris County in June of 1977.

This document, entitled Review and Refinement of the Regional Airport - Airspace System Plan Forecasts (2), projected aircraft numbers for the nine subareas of the county. The scope of the Master Plan which I was to prepare was limited to only the three western and northwestern subareas. It was necessary to allocate the aircraft forecasted for the aforementioned three subareas to the existing airports in the region. This task required some judgment since certain intangible factors had to be considered. For example, the majority of aircraft owners basing aircraft to the west and northwest of Houston prefer to be located at Lakeside Airport in the western area of the county due to proximity to the city. Unfortunately, the facilities at Lakeside are not adequate to handle the total projected demand. Accordingly, some of the aircraft that would want Lakeside basing "spill over" to David Wayne Hooks Memorial Airport (Hooks) northwest of Houston. Tempering the above consideration is the need to account for a reasonable amount of improvements to Lakeside over the 20-year period of the study. The percentage projections shown in Table I represent an allocation of projected

aircraft to western and northwestern Harris County considering both user preference and facility requirements.

TABLE I

Allocation of Aircraft to Western and Northwestern Harris County (Percent)

	1982	1987	1997
Western Harris County	36.5	43.3	44.4
Northwestern Harris County	63.5	56.7	55.6

With the percentages of Table I determined, a more detailed breakout for Hooks could be established. See Table 2 of Appendix A. The division of the total number of planes for 1982, 1987, and 1997 reflects the following assumptions:

1. The trend towards larger, more sophisticated business aircraft will continue.
2. The twenty-year period of the study will see higher percentages of turbine powered airplanes.
3. The trend of reduction of perce tage of aircraft in the small, single-engine category will continue. This assumption is tempered somewhat by the expected sustained growth of the flying

schools at Hooks. These schools use primarily single-engine aircraft.

4. Multi-engine piston planes will stay at approximately the same percentage over the next 20 years.

The above assumptions represent a compromise between national and local trend data.

Phase I: Determination of Facility Requirements

In this section of the Phase I report I attempted to specify what facilities, landside and airside, would be required to accommodate the forecasted numbers of aircraft for northwestern Harris County. The square footage figures given for the landside facilities in Appendix A represent prudent planning values and are based upon the firm's past experience with general aviation airports. The airside facilities that I recommended are consistent with FAA regulations for the types of aircraft forecasted over the period of the study.

Phase I: Engineering Evaluation of Hooks Airport

Harris County had designated Hooks airport as the "facility of primary interest" in the Master Plan in anticipation of possible County acquisition of the Hooks property. Accordingly, the County had requested that TCB accomplish an Engineering Evaluation of Hooks. In order to accomplish this task I made two trips to Hooks. The intent of the survey was to determine the condition of the

facilities at the airport and to ascertain if expansion to handle the projected increase in general aviation demand was technically feasible. Table 9 of Appendix A, the capacity analysis for the airport, was prepared in accordance with Techniques for Determining Airport Airside Capacity and Delay, a document issued as National Technical Information Service Report AD-A032475 in June 1976 by the U.S. Department of Commerce. The analysis showed that Hooks would be inadequate in its present configuration to handle the forecasted increase in operations by around 1986. As noted in Appendix A, I determined that expansion at Hooks was technically feasible.

Phase I: Site Selection

In this part of the Phase I report I presented TCB's evaluation of various alternative sites in Northwestern Harris County for the reliever airport. The County, as noted in the last section, had designated Hooks airport to be of primary interest in the Master Plan. However, several other areas had to be considered in the event that Hooks proved to be unacceptable. Appendix A delineates criteria used to compare each proposed site for the facility. The outcome of this particular section of the report was the selection of Hooks as the best airport location.

[illegible]

The [illegible]

general [illegible]

[illegible] The [illegible] requires [illegible]

Model (INM) to estimate the [illegible]

by the operation [illegible] airport [illegible]

a "box model" approach [illegible]

smaller airports [illegible]

required for both the [illegible]

are described below.

The INM allows the airport [illegible]

computer the expected scenario [illegible]

airport. Input to the computer is extensive [illegible]

to assume traffic mixes for the recommended [illegible]

based upon the demand projections developed [illegible]

1987, and 1997 earlier in the report. The mix assumptions

are listed below.

1. 80 percent of the airport operations (an operation is a landing or a takeoff) occur during the day and 20 percent during the evening for Visual Flight Rules (VFR) which prevail during conditions of adequate visibility.
2. 70 percent of the forecasted operations occur during the day, 20 percent during the evening, and 10 percent during night for Instrument Flight Rules (IFR) which prevail during bad weather or

[illegible] the 1987 and 1997 [illegible] student capability would be [illegible].

[illegible] all turbine [illegible] and single-engine [illegible] were assumed to use the [illegible] except during IFR conditions. [illegible] IFR conditions 5 percent of the single-[illegible] were [illegible] the parallel runway planned to be completed by 1987. [illegible] 1987 [illegible] turboprop and turbojet [illegible] were assumed to [illegible] the tower runway.

4. The [illegible] was assumed to equal the number of [illegible] by aircraft type.

5. Of all the operations forecasted, [illegible] percent [illegible] during VFR conditions and 25 percent during IFR conditions.

6. 91 percent of all operations occur on a runway bearing of 170 degrees and 11 percent on a bearing of 350 degrees.

Assumptions 1 and 2 were needed because the INM automatically increases the impact of noise generated during the evening and the night compared to noise effects during daylight hours. Operations had to be broken out by day, evening, and night.

Assumption 3 reflects the fact that the turboprop and turbojet aircraft predicted for Hooks will require a longer

runway than the [illegible] type aircraft [illegible] single-engine piston aircraft used [illegible] for instrument flying training. [illegible] navigational aids were designated for installation [illegible] the new runway.

Assumption 4 was based upon the [illegible] past experience with general aviation facilities. No data were available for Hooks.

Assumption 5 was needed for the aircraft track allocation that will be explained later in this report. A separate approach track was necessary for ILS instrument landings.

Assumption 6 was based upon the wind rose of prevailing winds for Hooks. Approximately [illegible] percent of the time winds are from the south and [illegible] percent of the time from the north.

In conjunction with the above assumptions, I also had to estimate the approximate ground tracks that the aircraft would reasonably be expected to follow in the future. Since Hooks is currently an uncontrolled facility, the current tracks followed at the airport are widely variant. The tracks finally selected and depicted in Appendix A (Exhibits A1 and A2) represent typical tracks for the controlled general aviation facility that Hooks would become if the County assumed ownership.

[illegible]

[illegible] other general aviation [illegible] general aviation [illegible] data base. By the assumptions [illegible] Appendix A. Now I had to further [illegible] aircraft by the following types [illegible] are these:

Light Single Engine Piston 2 seats (LSEP2)
Light Single Engine Piston 4 seats (LSEP4)
Medium Single Engine Piston 6 seats (MSEP6)
Light Twin Engine Piston 4 seats (LTEP4)
Medium Twin Engine Piston 10 seats Quiet (MTEP10Q)
Medium Twin Engine Piston 10 seats Loud (MTEP10L)
Medium Twin Engine Turboprop (MTETP)
Medium Twin Engine Turbofan (MTETF)
Light Quiet Turbofan (LQTF)

Tables II through V reflect the percentages that I [illegible] to use for each aircraft classification.

[illegible]

Aircraft Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes:

[illegible] aircraft [illegible] increased [illegible] airplanes [illegible]

[illegible] passenger aircraft [illegible] Master Plan [illegible]

TABLE III

[illegible]

Aircraft Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes:

1. [illegible] percentages [illegible] piston aircraft [illegible] medium [illegible] aircraft over the period of the Master Plan.

2. Additionally, the percentages reflect the assumption that people will become more concerned about purchasing less noisy aircraft with time. New FAA regulations with regard to acceptable noise levels of aircraft will be [illegible] by the year [illegible]

TABLE IV

Apportionment of Forecasted Multi-Engine Turboprop Aircraft (Percentage)

Aircraft Type	1978	1982	1986	1987	1997
MTETP	100	100	100	100	100

Note:

There is only one MTETP noise envelope loaded into the data base of the INM. Hence, all aircraft in this category were assigned the MTETP type.

TABLE V

Apportionment of Forecasted Turbofan Aircraft (Percentage)

Aircraft Type	1978	1982	1986	1987	1997
MTETF	30	30	60	60	60
LQTF	70	70	40	40	40

Notes:

1. Above percentages assume a transition from lighter turbofan aircraft to heavier as the new runway is completed.

2. Ideally the data base of the INM should include a medium quiet turbofan (MTETF QT). Unfortunately, no such input was possible. Accordingly, the trend to larger aircraft limited selection to the rather noisy MTETF currently in the data base. This restriction definitely resulted in noise contour projections that were somewhat conservative for 1987 and 1997.

The output from the INM consists of an echocheck of the input data, the coordinates of the decibel levels of interest around the runway(s), and a plot of the contour levels of interest. For planning purposes, the analyst's

main concern focuses on the location of the 65 and 75 decibel noise contours about the runway. The 65 decibel level is the "threshold of complaint" at which noise sensitive entities bordering an airport will begin to complain about the airfield's operations. Noise levels above 75 decibels should be confined to the airport boundaries.

The plotted contours (Exhibits 4 through 7 of Appendix A) when superimposed on an aerial photograph of the area surrounding Hooks showed that the noise impact increased over the period of the study as expected. Careful planning on the part of the county would be required to ensure that noise sensitive areas were kept beyond the 65 decibel contour.

Although the INM is an effective planning tool, the question arises concerning whether the model has ever been verified by comparison of results to actual field measurements. I queried the FAA concerning validation (see Appendix C). The FAA's response was that validation "is ongoing," that is, definitive verification of the INM has not been completed.

With respect to the air quality analysis, the "box model" approach recommended by the FAA for smaller airports such as Hooks assumes that each aircraft utilizing the runway emits pollutants into a box of specified dimension. The level of pollution is linked to the number of peak

[illegible] landings and take offs [illegible] LTO [illegible] An LTO [illegible] [illegible] and take off [illegible] [illegible] pollutant are multiplied times the number of LTO's to derive an estimate of air quality impact (see Appendix A for a more detailed explanation of the air quality analysis that I performed for Hooks).

The box model is certainly an expedient means to arrive at the expected impact of projected aircraft operations. Unfortunately, the model makes at least one questionable assumption. The model presumes that the wind velocity, an important consideration in the dispersion of contaminants, in the box is a constant one meter per second. This wind velocity is intended to simulate a "worst case" or near zero wind speed situation. I queried the FAA about the one meter per second velocity. Appendix C contains the FAA's response which indicates that the FAA has no information on the wind velocity assumption. Despite the FAA's answer, I felt that the small number of LTO's at Hooks would not cause significant adverse environmental impact upon the surrounding area.

Phase I: Summary and Conclusions

In the conclusion to the interim report I recommend that public acquisition of Hooks not be made. Although the airport would make an excellent reliever facility from an environmental and technical standpoint, the economic

feasibility of acquiring Hooks was questionable. (I address the costs of county acquisition of Hooks in the next section of this internship report.) Furthermore, by the time I had completed the interim report, Harris County officials had advised TCB that they preferred Lakeside Airport to the west of Houston and closer to Houston as the site of the reliever airport. I did recommend that county acquisition be seriously reconsidered if it became evident that Hooks would have to close for some reason.

Phase II: Economic Feasibility and Development Program - Introduction

Even though Harris County had indicated a preference for the Lakeside site their decision was by no means final. Completion of Phase II to the Airport Master Plan for Northwestern Harris County was important not only to satisfy TCB's contractual commitment but also to provide valuable information in the event that public acquisition of Lakeside became unfeasible. Tasks included in this Phase of the Master Plan involved preparation of 1) Airport Plans, 2) a Development Schedule of Proposed Improvements, 3) an Economic Feasibility and Financing Plan, and 4) an Environmental Impact Assessment Report.

Phase II: Airport Plans

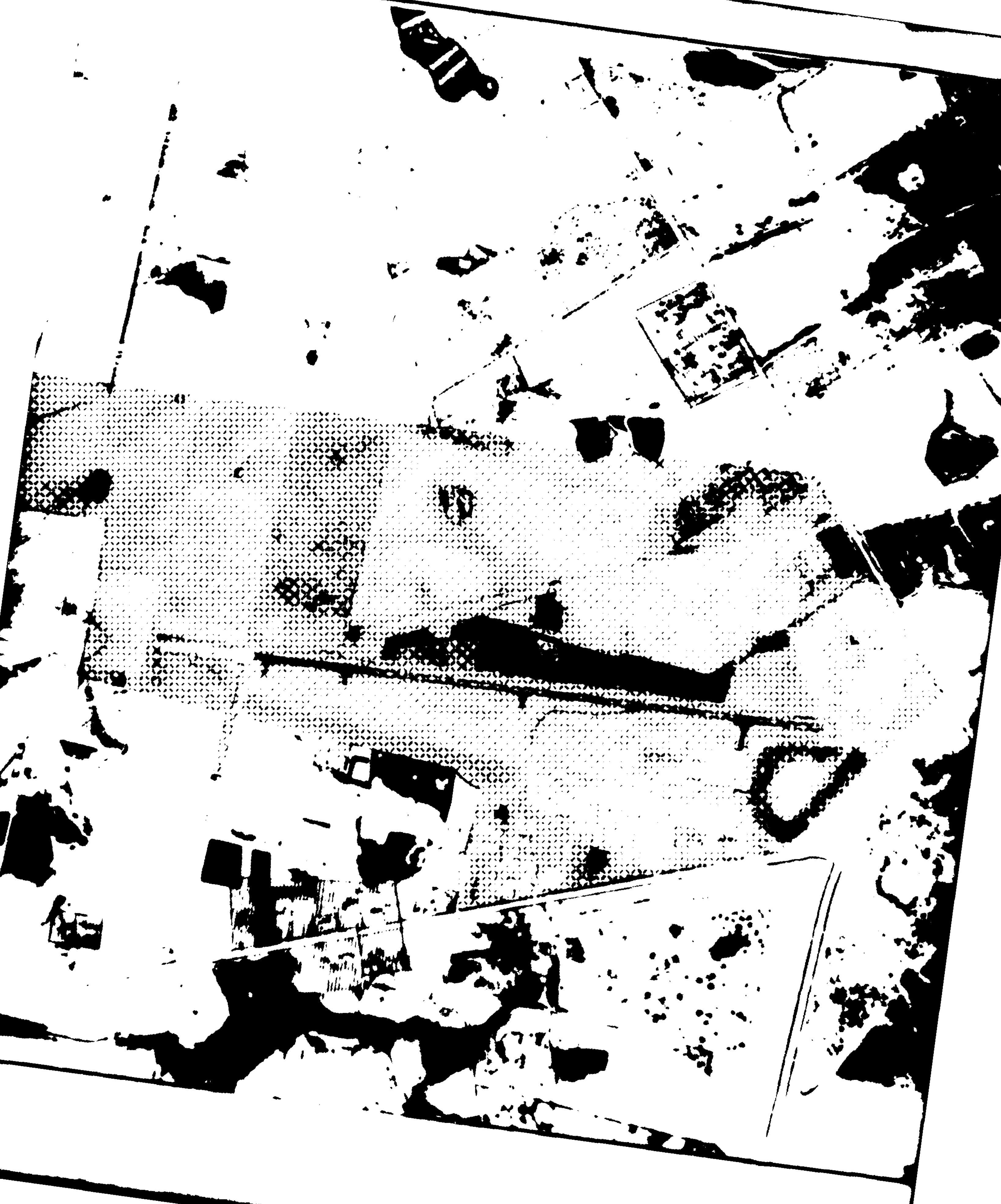
The airport plans required by the FAA in a Master Plan include an Airport Layout Plan (ALP), a Land-Use Plan, an Access Plan, and an Aerial Zoning Map. The ALP was incorporated into the Phase I interim report and is included in Appendix A. The other three plans are Figures 2, 3, and 4 of this internship report.

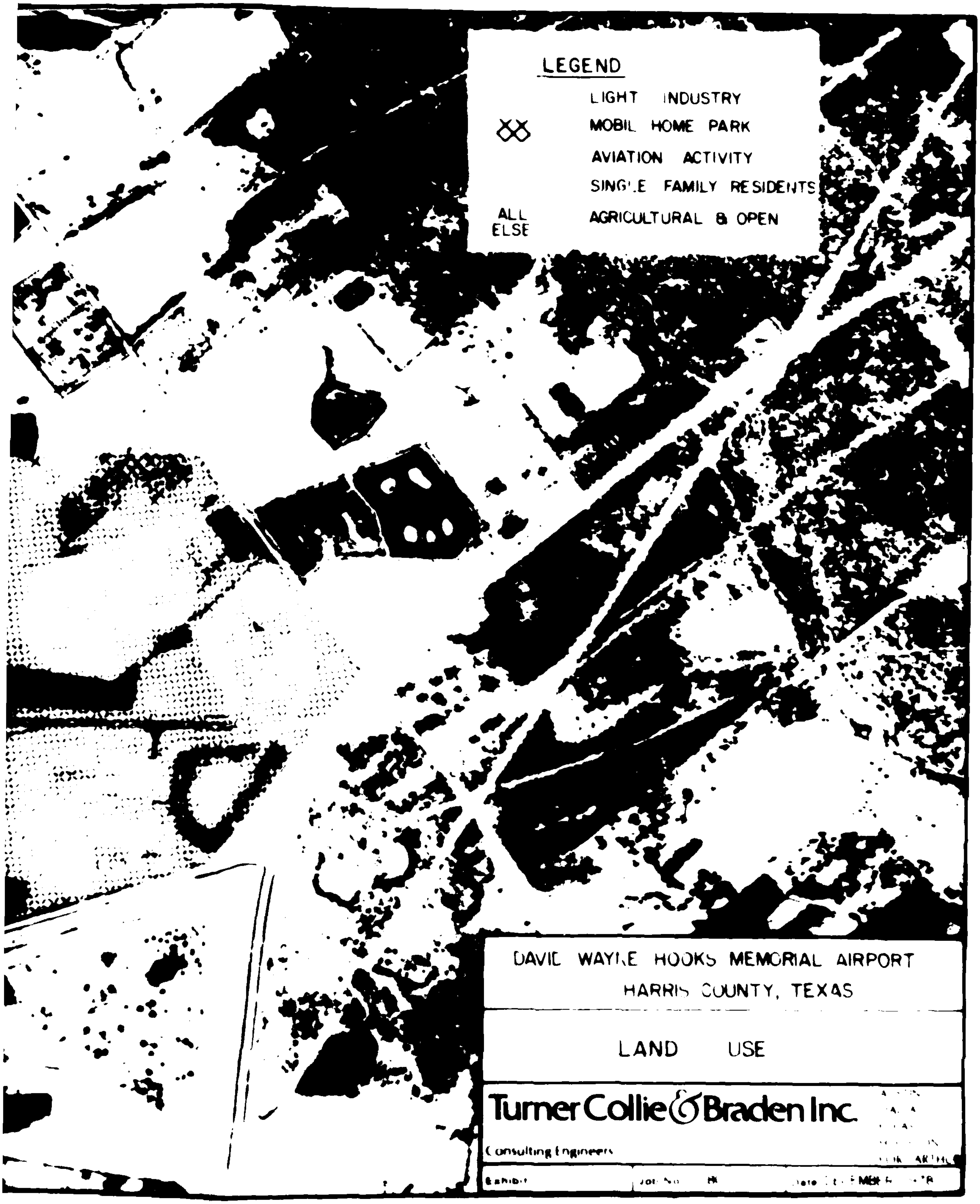
Phase II: Development Schedule

Table VI is the development schedule of proposed improvements for Hooks airport. The schedule allows for an orderly expansion of the facilities at Hooks to accommodate the projected increased demand over the period of the Master Plan. Naturally, Table VI reflects those improvements necessary assuming that Harris County were to acquire the airport.

Phase II: Economic Feasibility and Financing Plan

The purpose of this section of the Airport Master Plan is to evaluate the economic feasibility of the proposed development at Hooks. This task is undertaken to ensure that the airport operation would be "self sufficient," that is, the necessary revenues to recover the total cost of operating the airport are collected from the users of the airport and not from the taxpayers of Harris County.





LEGEND
LIGHT INDUSTRY
MOBIL HOME PARK
AVIATION ACTIVITY
SINGLE FAMILY RESIDENTS
ALL ELSE
AGRICULTURAL & OPEN
DAVID WAYNE HOOKS MEMORIAL AIRPORT
HARRIS COUNTY, TEXAS
LAND USE
Turner Collie & Braden Inc.
Consulting Engineers
Exhibit
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FUTURE
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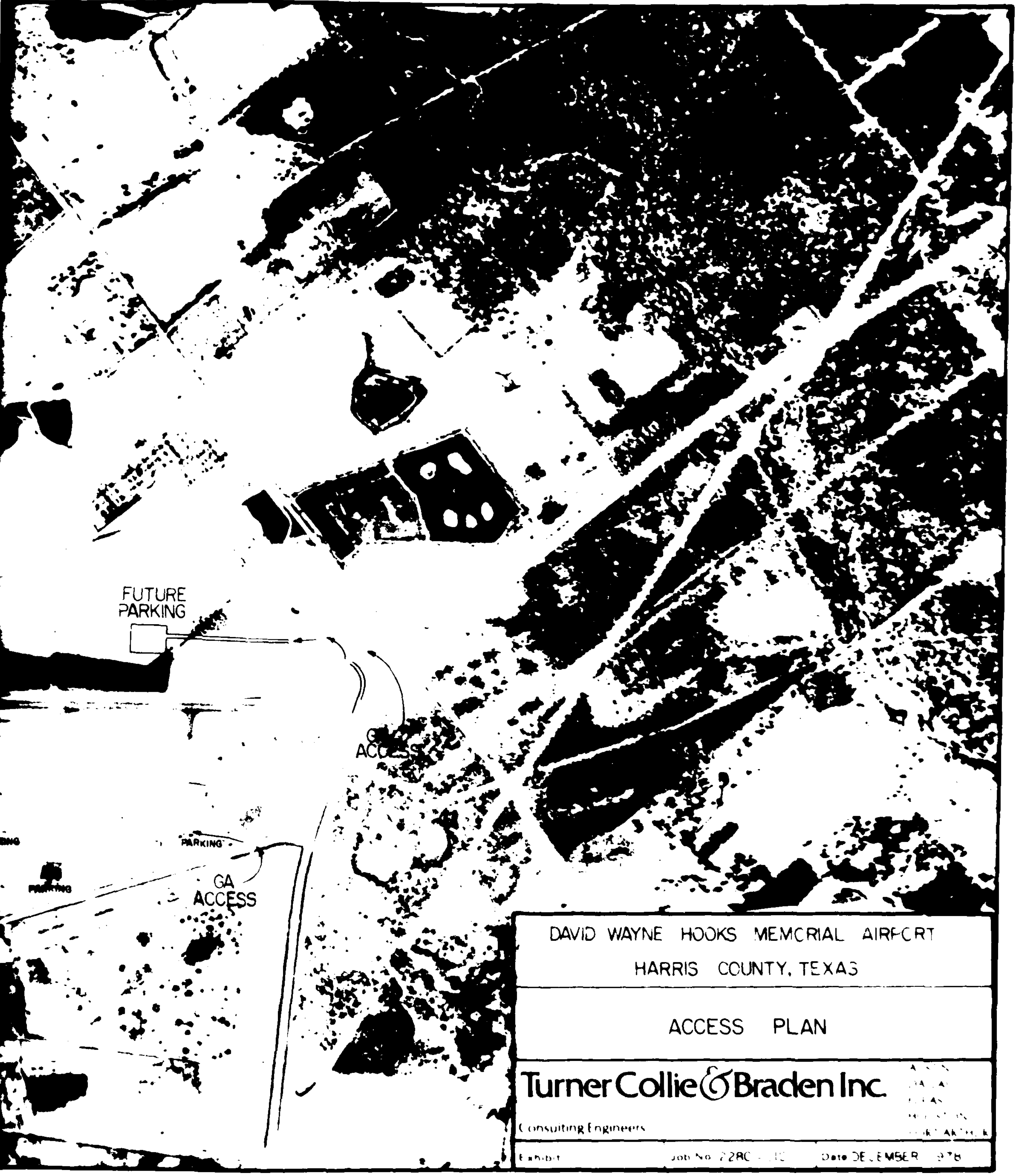


DAVID WAYNE HOOKS MEMORIAL AIRPORT

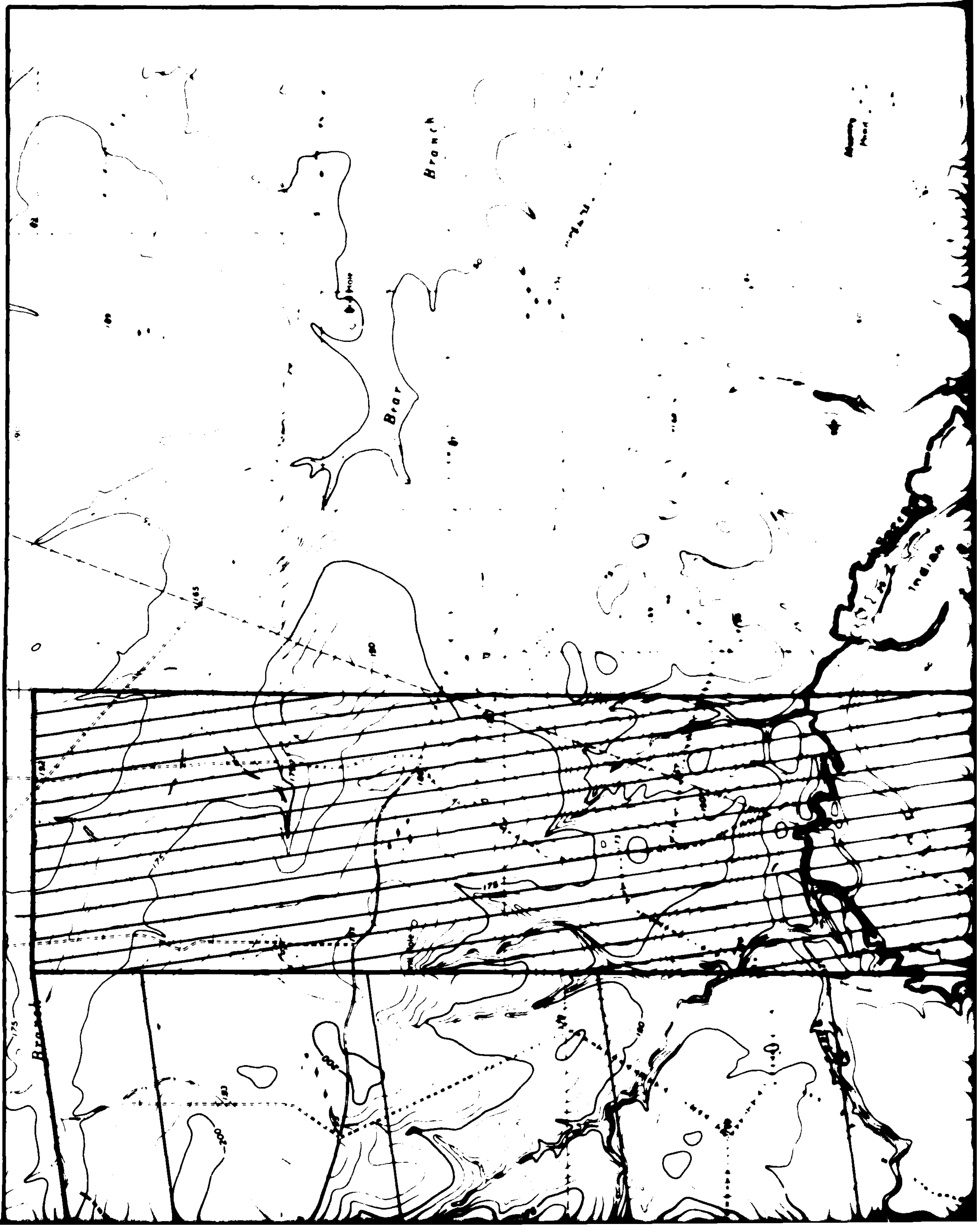
HARRIS COUNTY, TEXAS

ACCESS PLAN

Turner Collie & Braden Inc.

Consulting Engineers

Exhibit | Job No. 228C [illegible] | Date DECEMBER [illegible]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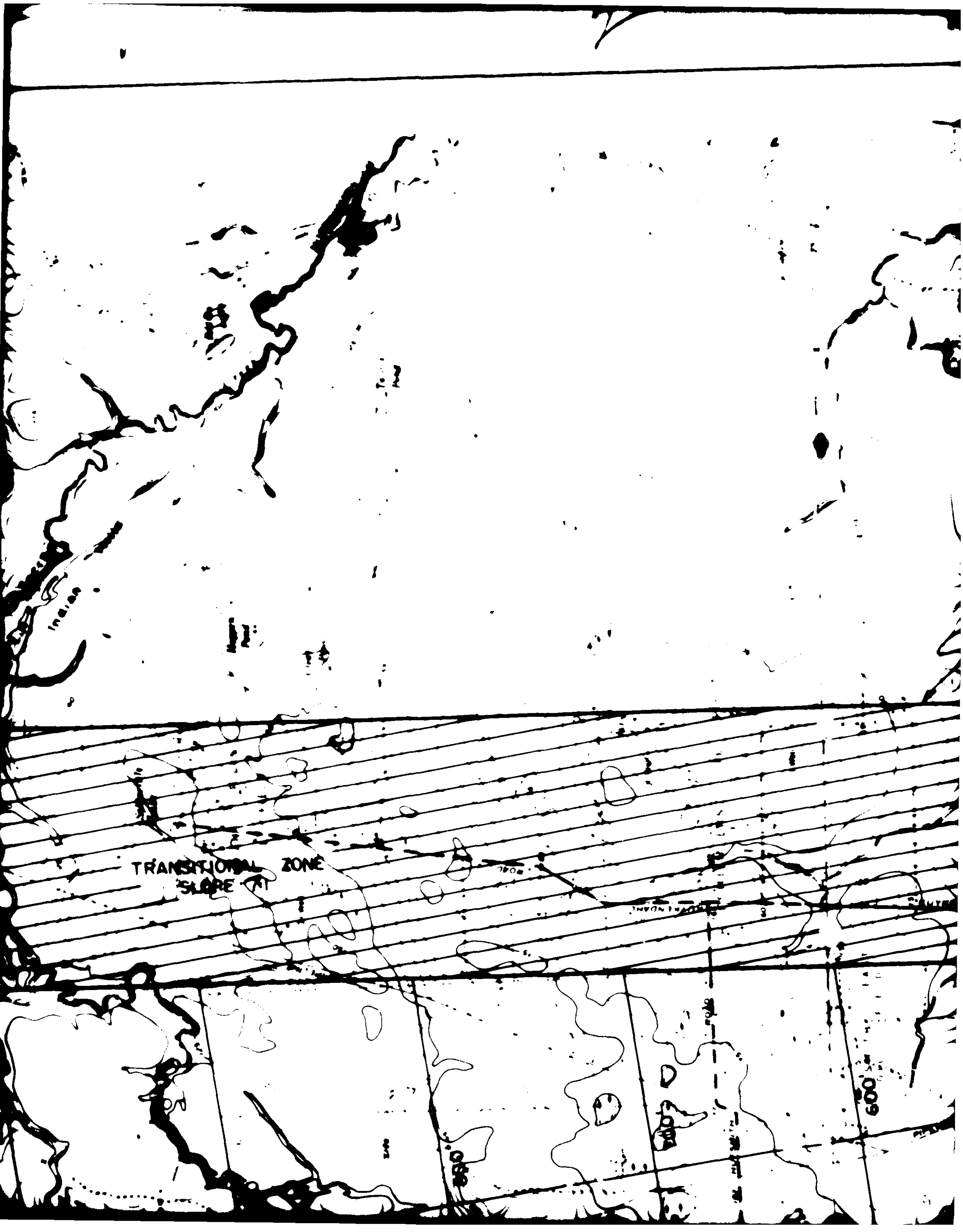
175
200


Indian
TRANSITIONAL ZONE
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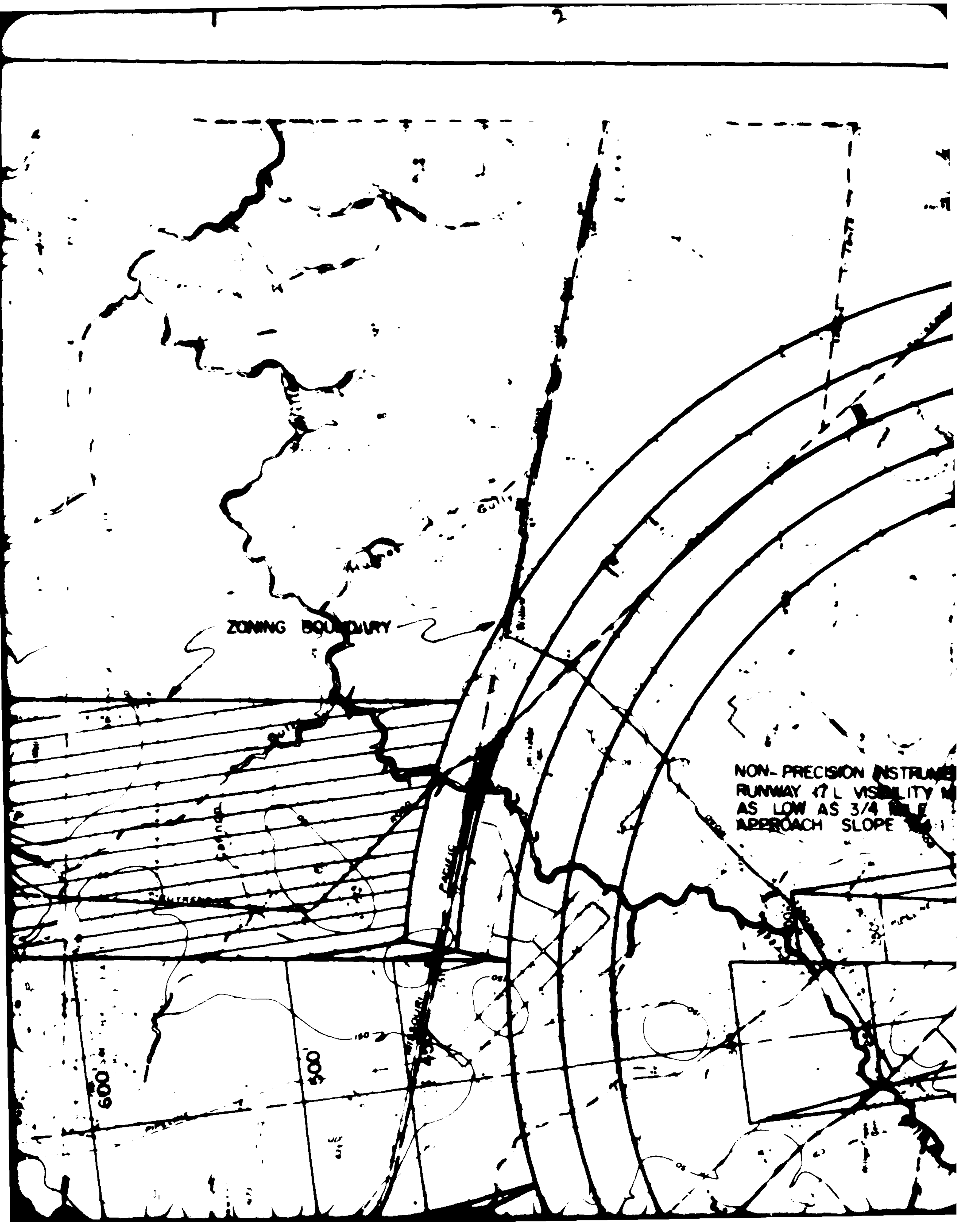
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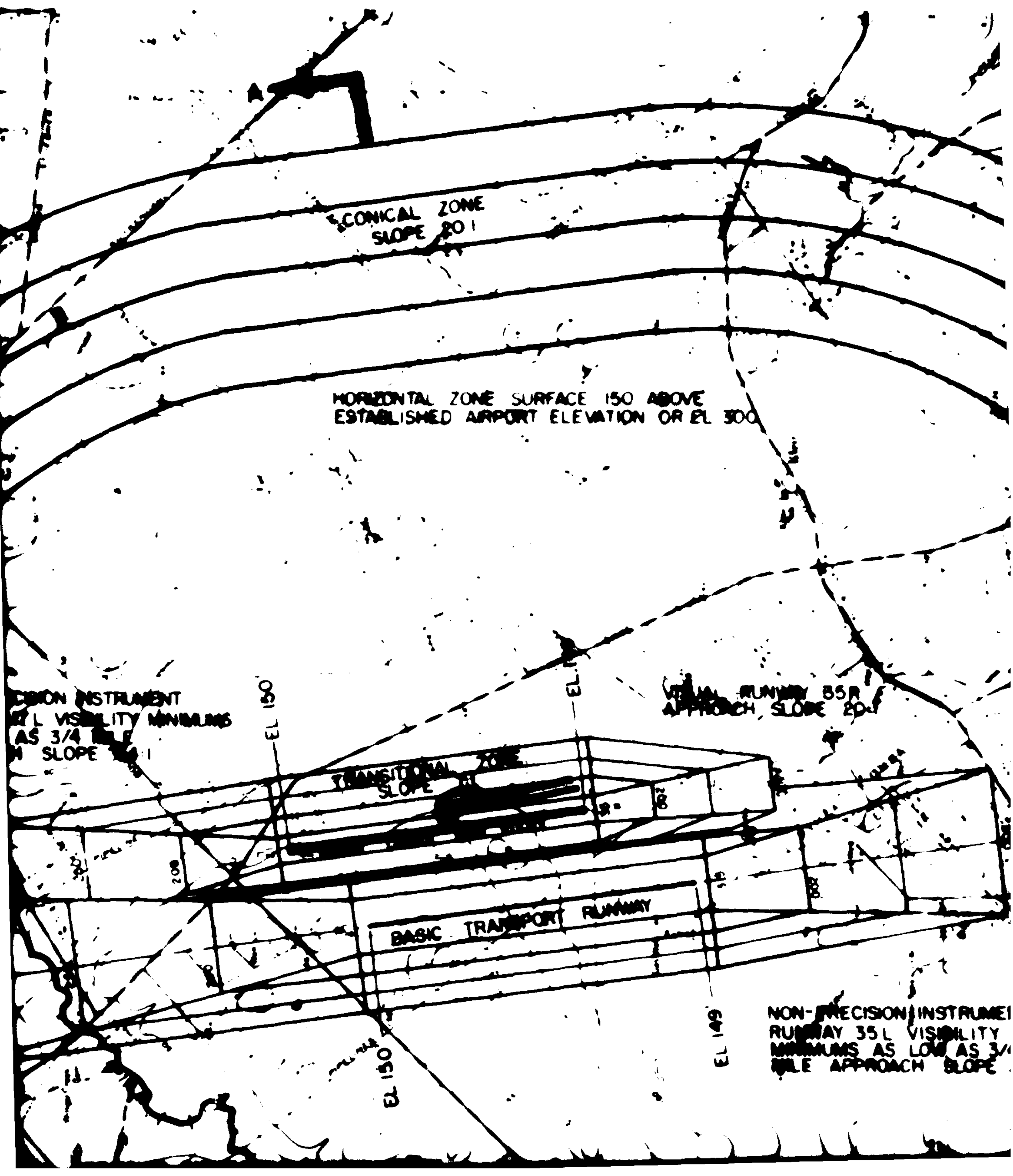
CONICAL ZONE
SLOPE 20 1
HORIZONTAL ZONE SURFACE 150 ABOVE
ESTABLISHED AIRPORT ELEVATION OR EL 300
EL 150
VISUAL RUNWAY 35R
APPROACH SLOPE 20
TRANSITIONAL ZONE
SLOPE
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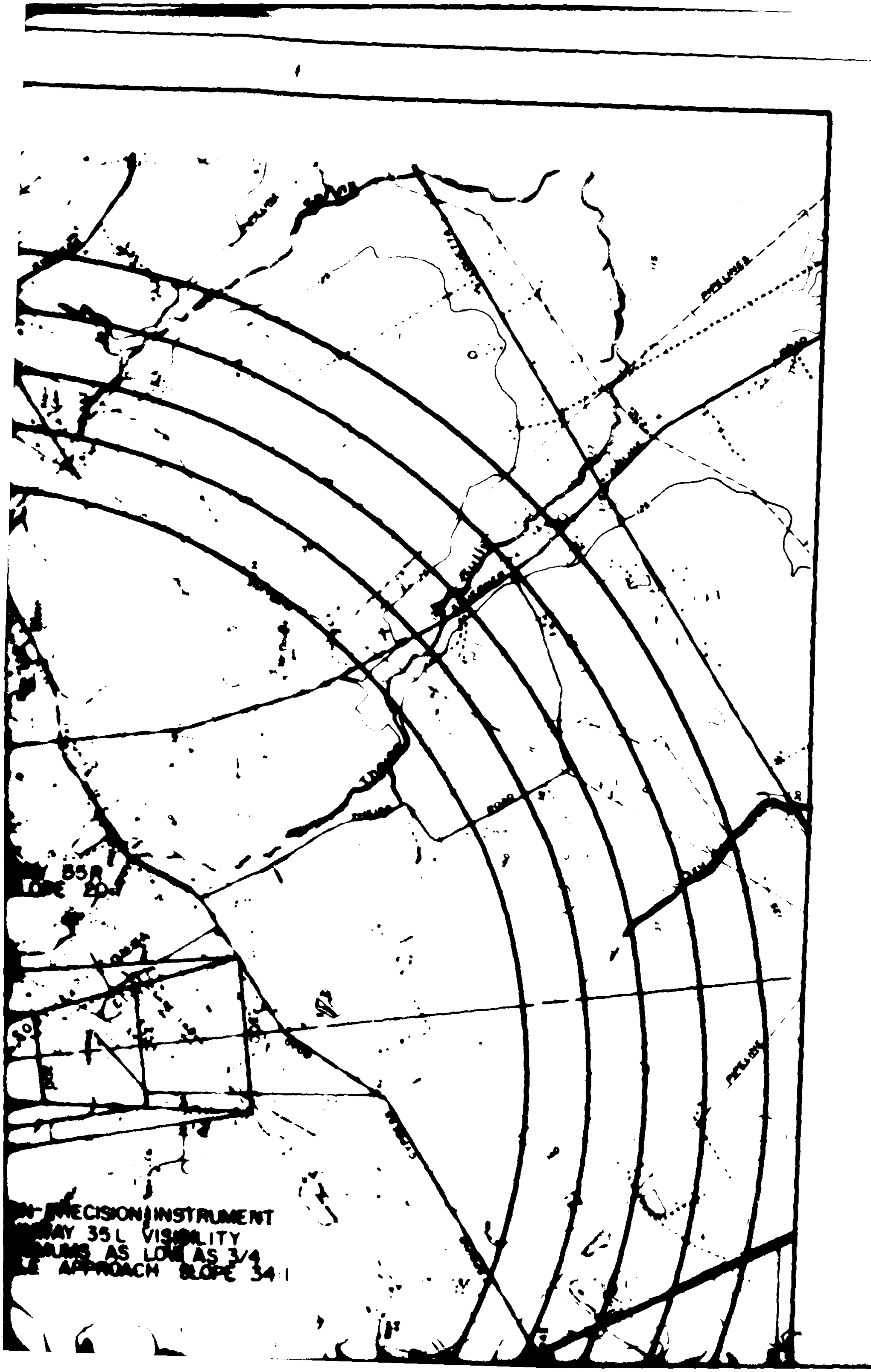
EL 150
EL 149
NON-PRECISION INSTRUMENT
RUNWAY 35L VISIBILITY
MINIMUMS AS LOW AS
MILE APPROACH SLOPE

5



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A
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1200
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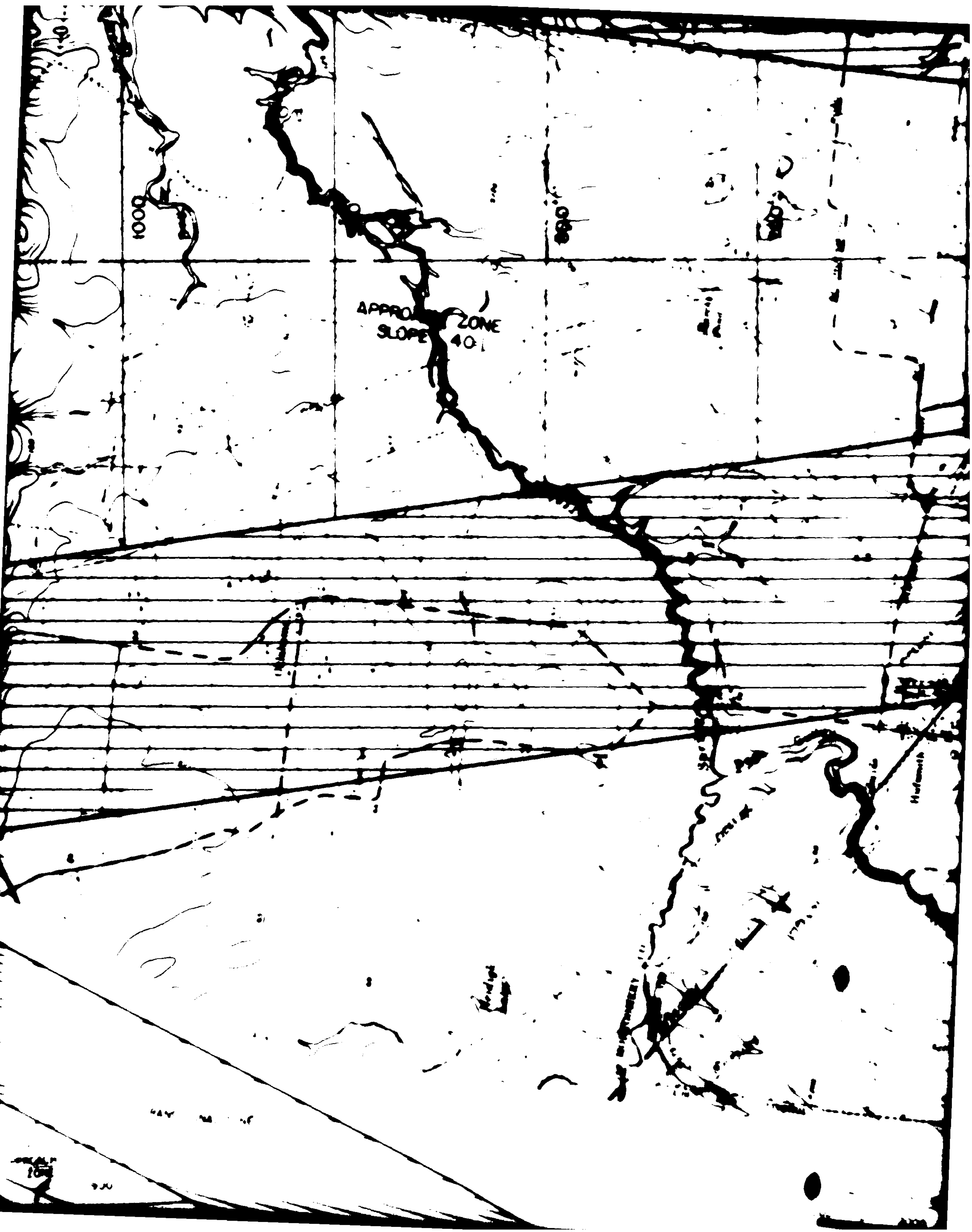
Drill Hole
Gravel Pits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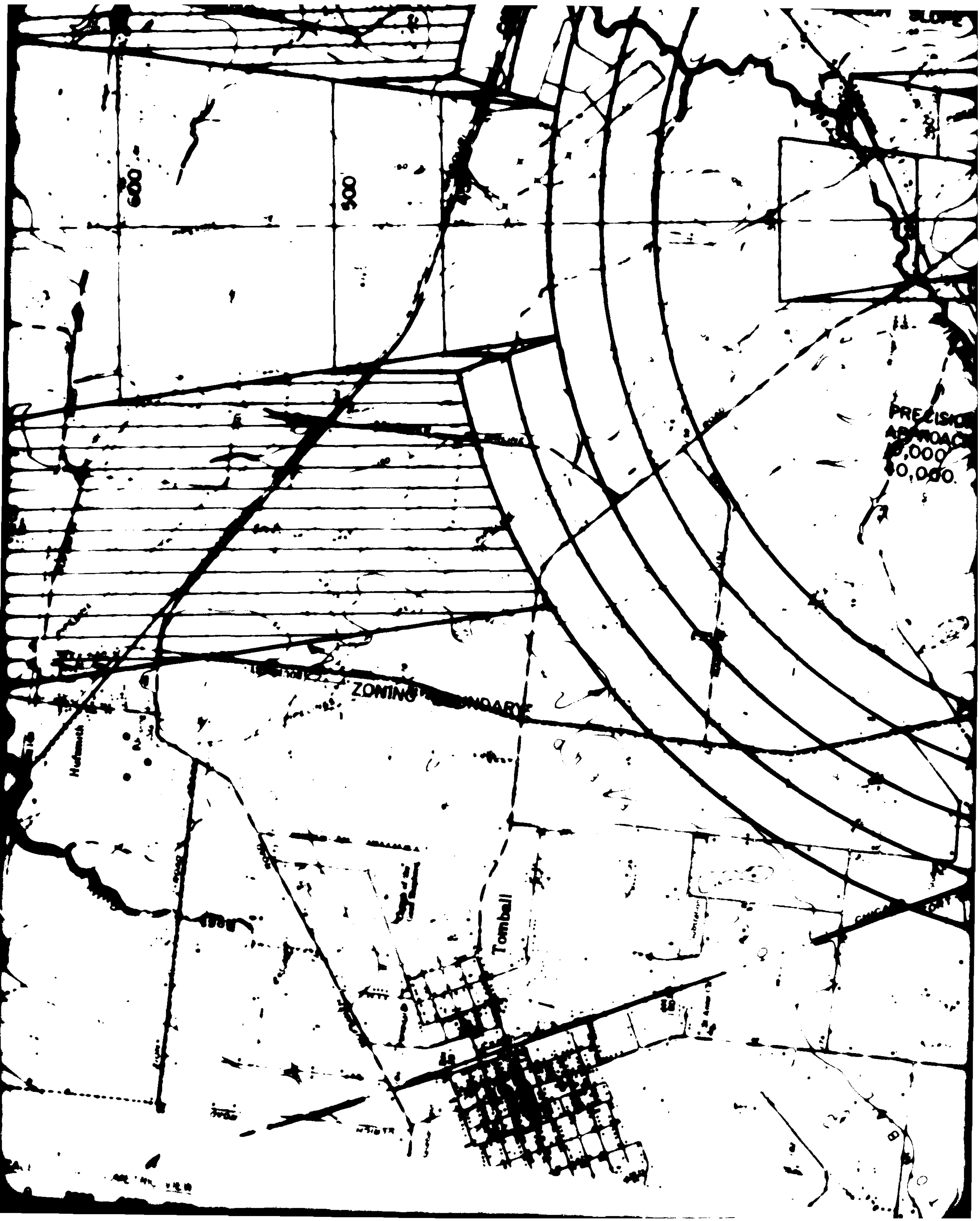
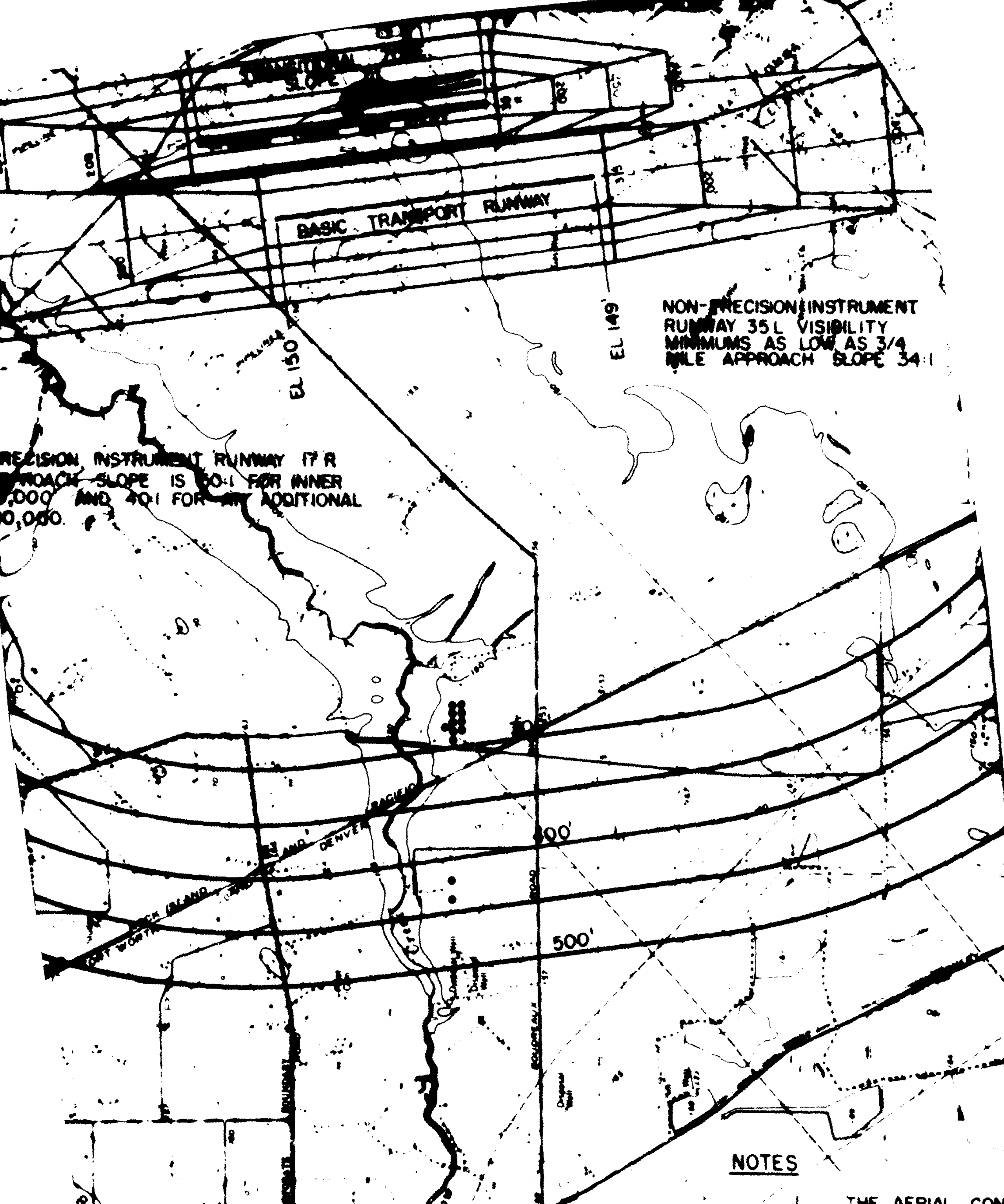

600
900
Tomball



NOTES

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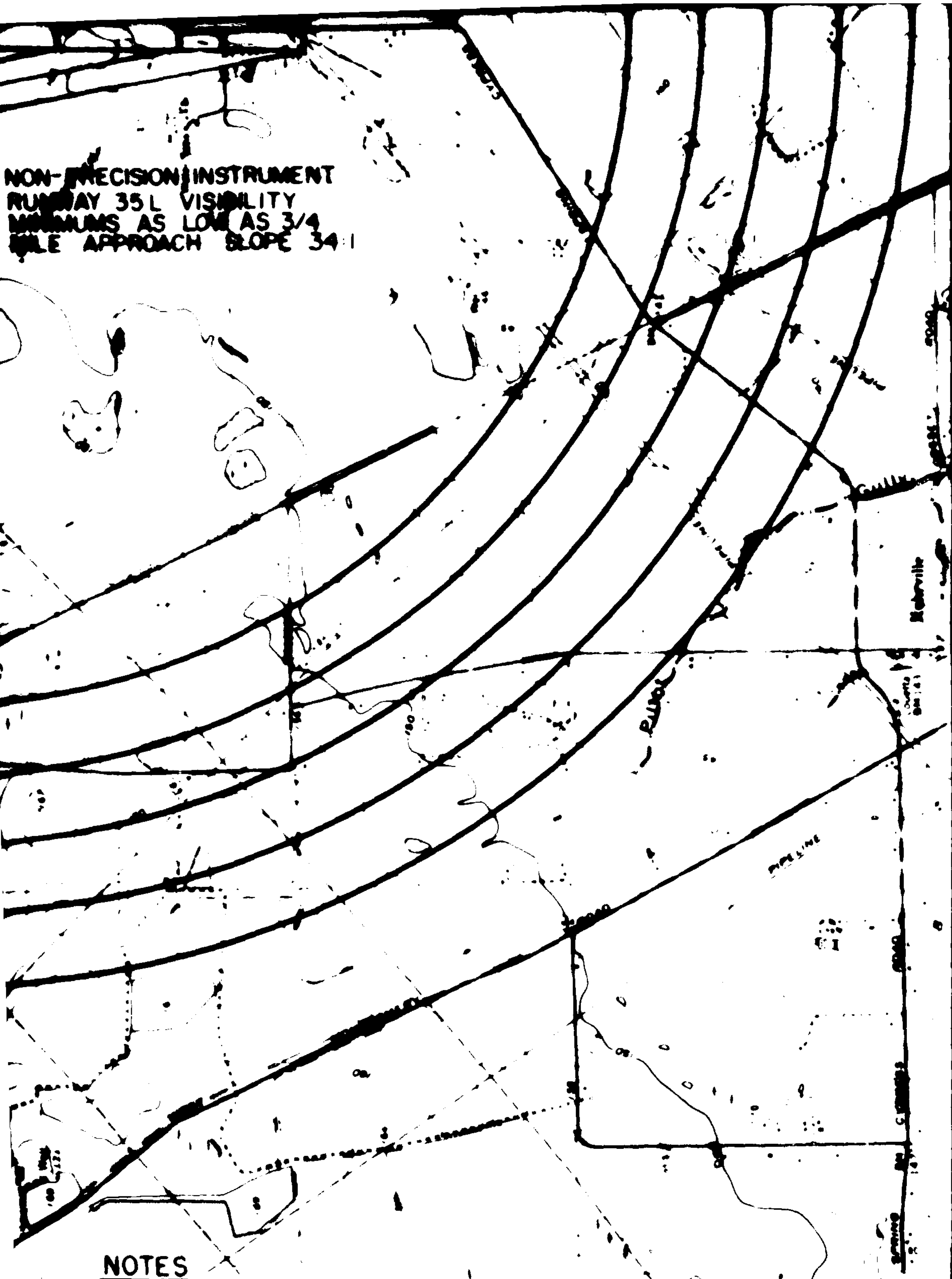
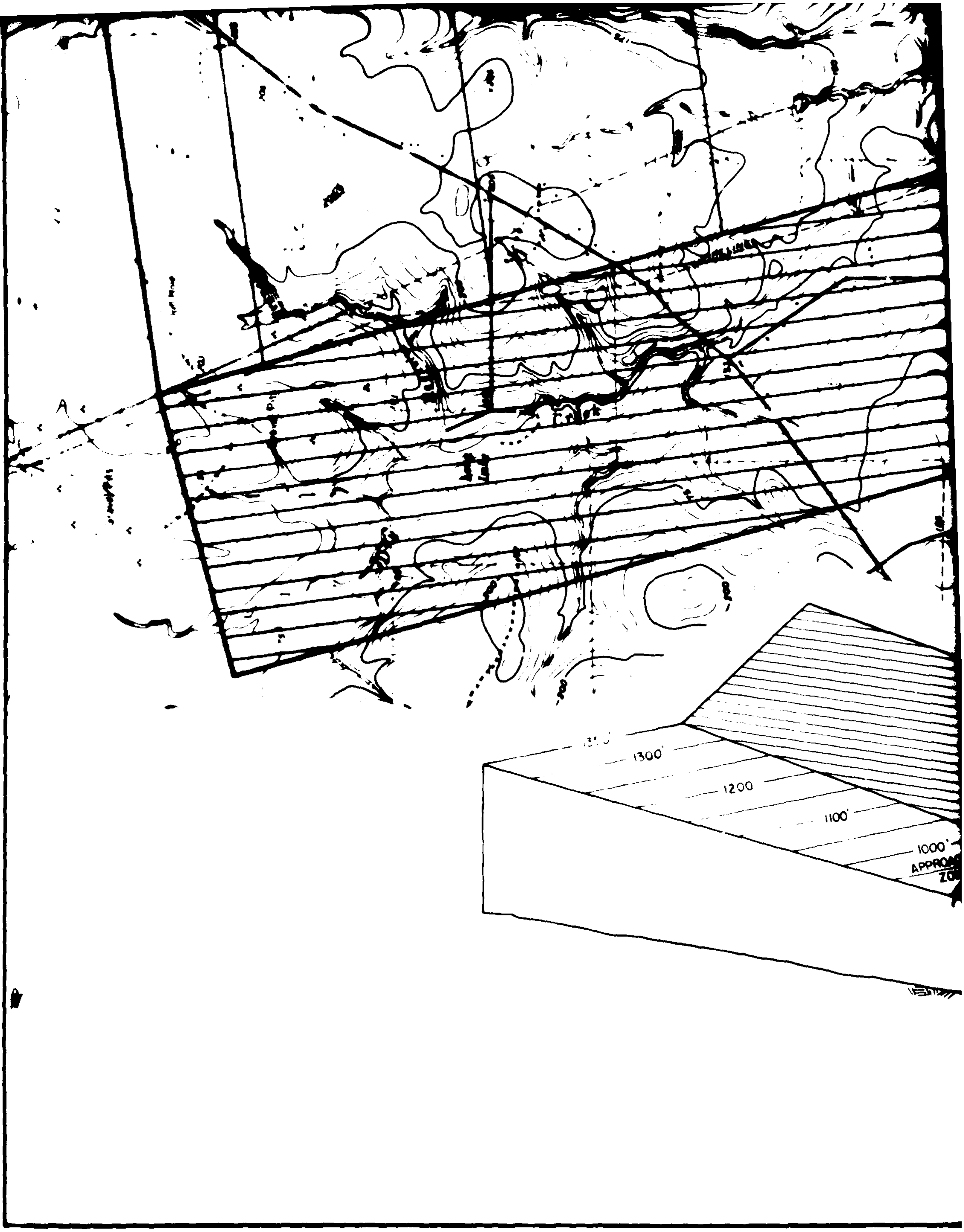


NOTES

1. THE AERIAL CONTOURS ILLUSTRATE THE HEIGHT LIMITATIONS WITHIN EACH ZONE
2. A SLOPE, SUCH AS 20:1, EXPESSES THE HORIZONTAL DISTANCE OF 20 FEET TO THE VERTICAL DISTANCE OF 1 FOOT
3. EXISTING TOPOGRAPHIC SYMBOLS ARE THOSE USED BY THE U.S GEOLOGICAL SURVEY
4. THE NORTH CENTRAL AIR STATE GRID SYSTEM IS USED



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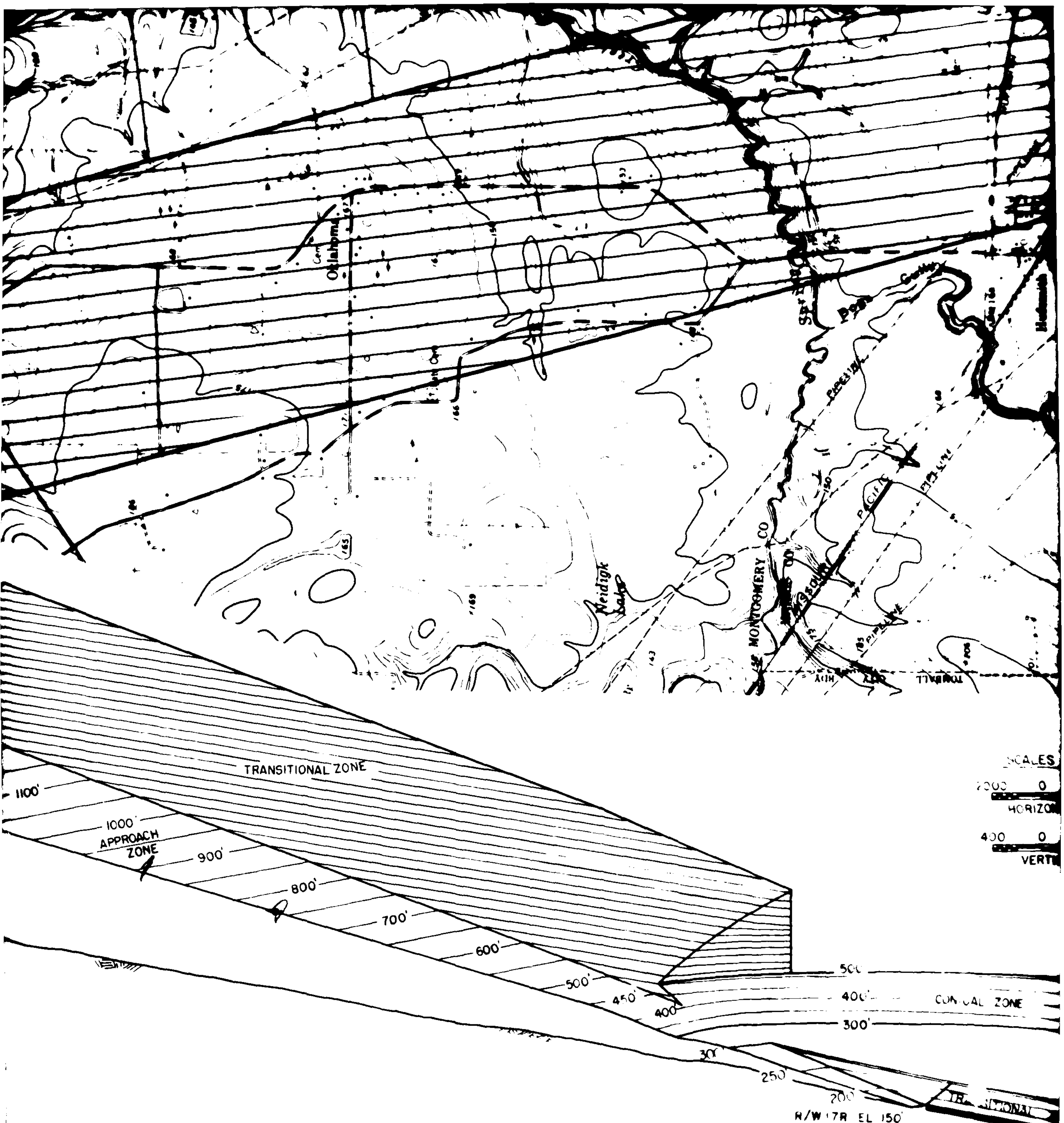
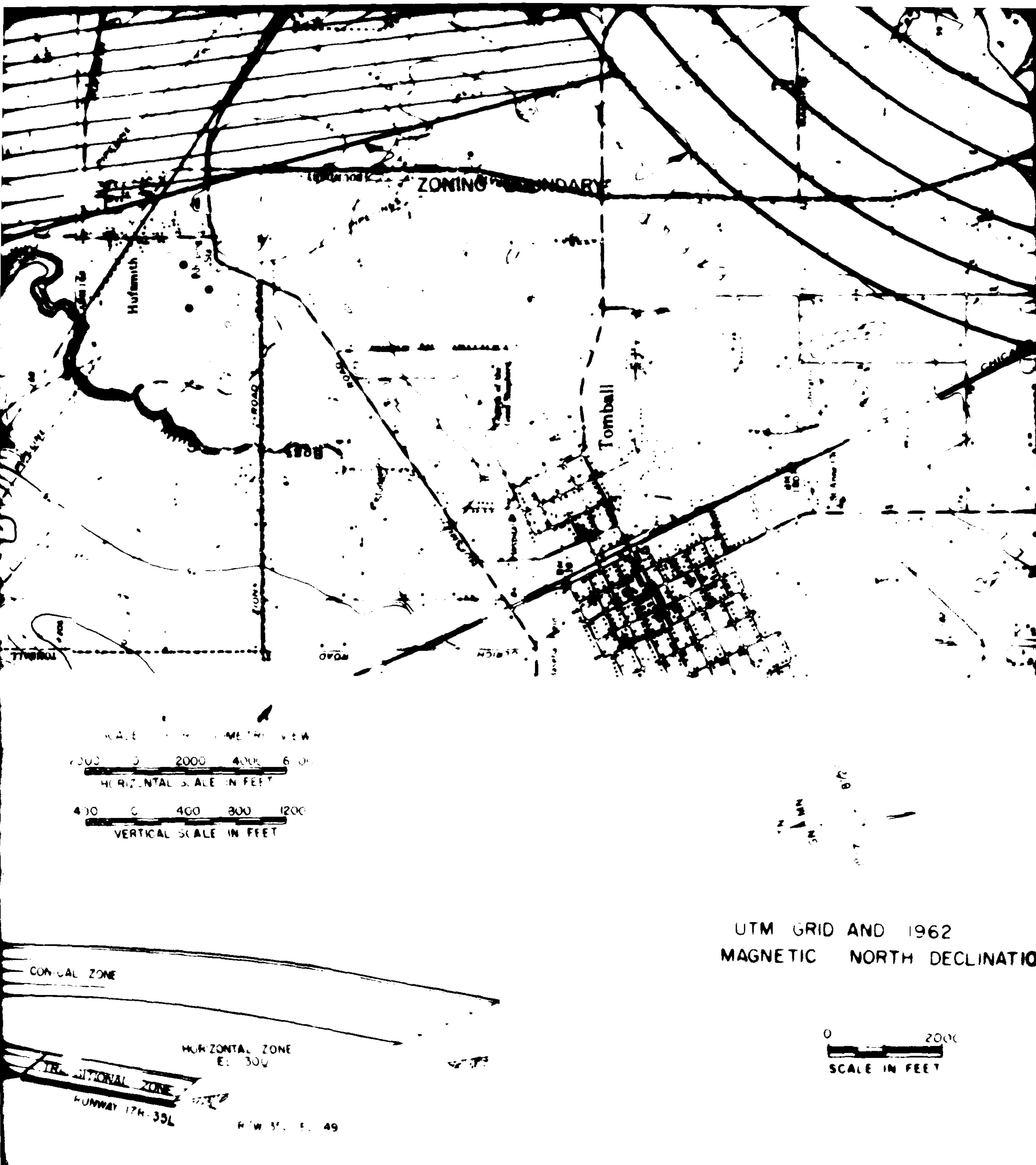


ISOMETRIC VIEW OF SECTION A-A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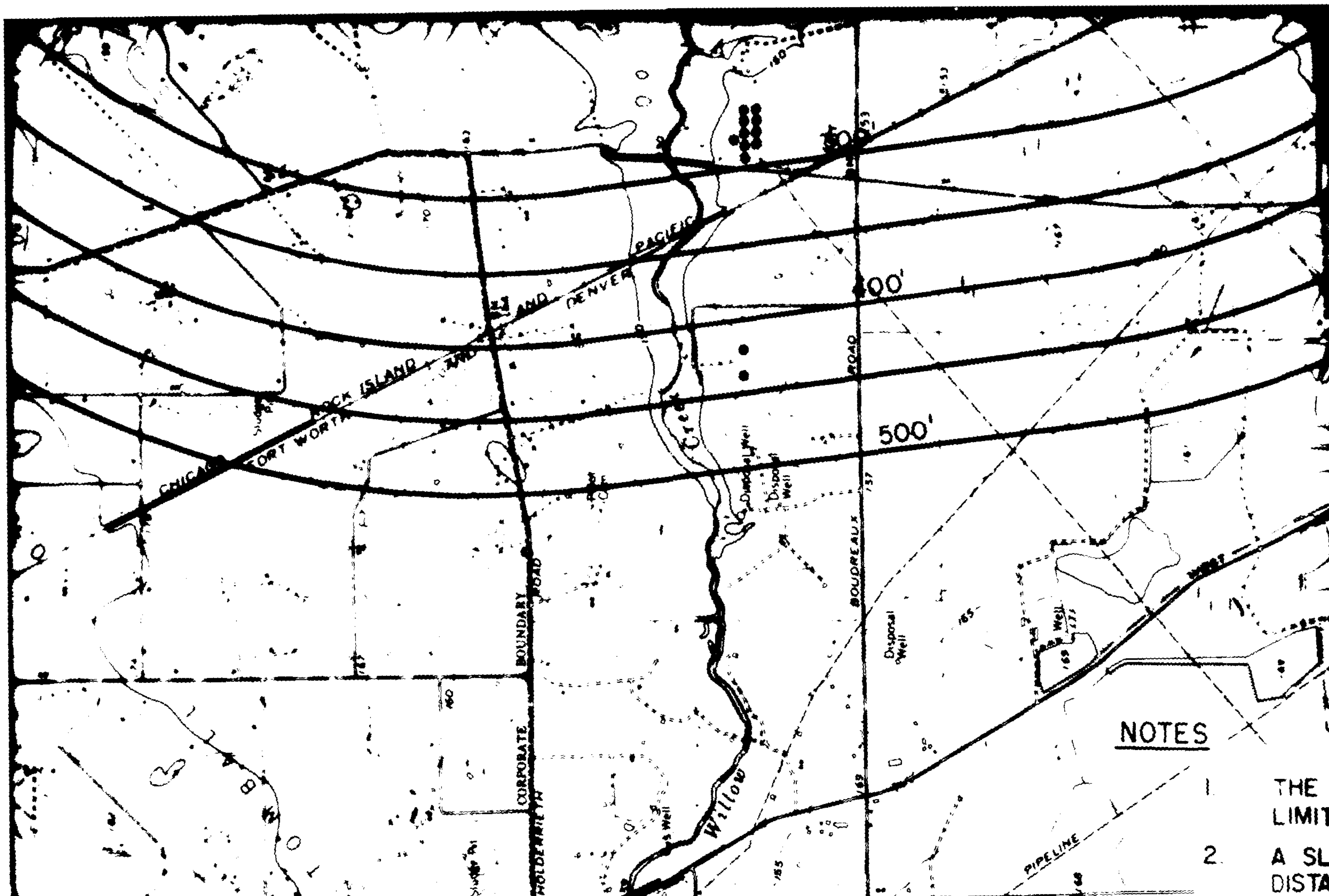
ROAD
HORIZONTAL SCALE IN FEET
VERTICAL SCALE IN FEET
UTM GRID AND 1962
MAGNETIC NORTH DECLINATION
SCALE IN FEET
HORIZONTAL ZONE
RUNWAY 17R-35L



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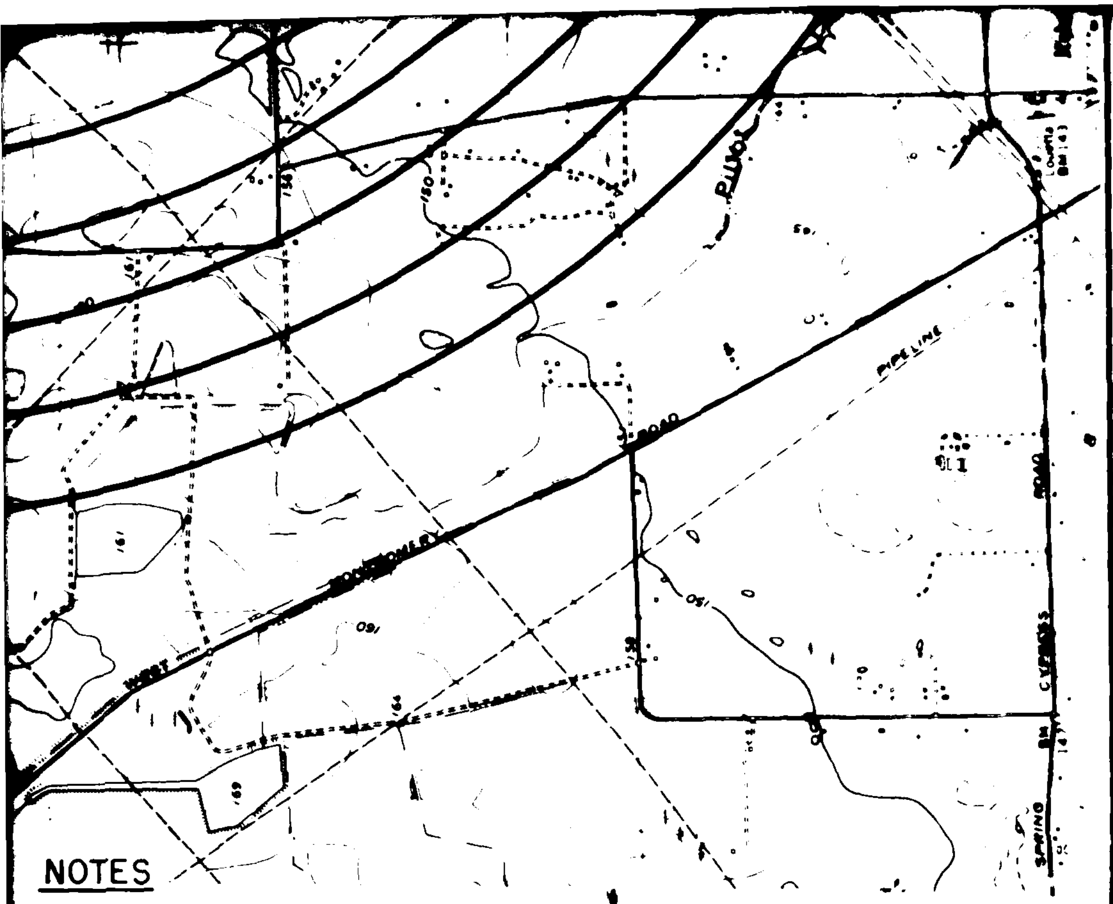
15



NOTES

1. THE AERIAL CONTOURS ILLUSTRATE THE HEIGHT LIMITATIONS WITHIN EACH ZONE.
2. A SLOPE, SUCH AS 20:1, EXPESSES THE HORIZONTAL DISTANCE OF 20 FEET TO THE VERTICAL DISTANCE OF 1 FOOT.
3. EXISTING TOPOGRAPHIC SYMBOLS ARE THOSE USED BY THE U.S. GEOLOGICAL SURVEY.
4. THE NORTH CENTRAL AIR STATE GRID SYSTEM IS USED.

DAVID WAYNE HOOKS MEMORIAL AIRPORT HARRIS COUNTY, TEXAS		
AERIAL ZONING MAP		
Turner Collie & Braden Inc. Consulting Engineers AUSTIN DALLAS HOUSTON PORT ARTHUR		
Exhibit	Job No 2280-010	Date DECEMBER 1978

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TABLE VI

Airport Development Schedule, D. W. Hooks Memorial Airport

First Phase Improvements (1978-1982)

1980

- Overlay existing airport pavement where needed.
- Construct general aviation hangars to accommodate 47 additional aircraft.
- Construct apron area and runway access taxiway.
- Install security fencing.
- Install visual aids.
- Extend taxiway parallel to existing runway.
- Demolish existing barn.
- Remove existing taxiway pavement and road where indicated on Airport Layout Plan.
- Acquire undeveloped adjacent land and obtain easements, approximately 752 acres for new runway and clear zones.
- Fill and level lake to provide runway safety area.

1981

- Construct general aviation hangars to accommodate 28 additional aircraft.

1982

- Construct general aviation hangars to accommodate 33 additional aircraft.

Second Phase Improvements (1983-1987)

- Construct 6,000 foot parallel runway with associated taxiways.
- Install precision approach navigational and visual aids.

TABLE VI (continued)

- Construct general aviation hangars to accommodate 35 additional aircraft.
- Construct crash, fire, and rescue building.

Third Phase Improvements (1988-1997)

- Construct general aviation hangars to accommodate 50 additional aircraft.

The cash flows necessary to determine the economic feasibility of the airport include:

- Capital expenditures for improvements.
- Annual operation and maintenance (O&M) expenses.
- Annual operating revenues.

The above quantities are estimated using available data on construction costs for capital improvements and information from the current owner of the airport as well as historical trends for O&M expenses and revenues. Each of the above inputs is discussed separately, in detail in the paragraphs to follow.

Capital expenditures are divided into three stages - 1978-1982, 1983-1987, and 1988-1997. Tables VII through IX depict the capital improvements with estimated costs for each stage of the twenty year study period. A seven percent inflation factor has been applied to each cost estimate. Fund sources for development include federal and state grants, bonds, and operating revenues. These sources are discussed later in this financing plan.

TABLE VII

Capital Expenditures First Stage (19[illegible]-19[illegible]),
D. W. Hooks Memorial Airport

Landside Facilities	
Additional General Aviation Hangar Construction	$1,040,000
Construct New Apron Area	380,000
Install Security Fencing	292,000
Demolish Existing Barn	15,000
Fill and Level Lake to Northeast of Existing Runway	418,000
Subtotal Landside Facilities	$2,145,000
Airside Facilities	
Overlay Airport Pavement	$ 158,000
Install Visual Aids	198,000
Extend Taxiway Parallel to Existing Runway	88,000
Remove Existing Taxiway where Designated on Airport Layout Plan	49,000
Subtotal Airside Facilities	$ 493,000
Total First Phase Upgrade and Construction	$2,638,000
Land Acquisition	$5,576,000
Engineering and Contingencies	528,000
Total Project First Stage	$8,742,000

TABLE VIII

Capital Expenditures Second Stage (1983-1987),
D. W. Hooks Memorial Airport

Landside Facilities	
Additional General Aviation Hangar Construction	$ 430,000
Construct Crash, Fire, and Rescue Facility	16,000
Subtotal Landside Facilities	$ 446,000

TABLE VIII (Continued)

Airside Facilities	
Construct 6,000 Foot Parallel Runway with Associated Taxiways	$ 940,000
Install Precision Approach Navigational and Visual Aids	650,000
Subtotal Airside Facilities	$1,590,000
Total Second Stage Construction	$2,036,[illegible]
Engineering and Contingencies	407,[illegible]
Total Project Second Stage	$2,44[illegible]

TABLE IX

Capital Expenditures Third Stage ([illegible])
D. W. Hooks Memorial Airport

Landside Facilities	
Additional General Aviation Hangar Construction	$1,010,[illegible]
Engineering and Contingencies	202,00[illegible]
Total Project Third Stage	$1,212,[illegible]

Four main categories of O&M expenses exist at Hooks as follows:

- Grounds Maintenance
- Hangar Maintenance
- Administration
- Security

For Hooks Airport very little historical O&M information is available from which an expense pattern can be extrapolated

to future years. The projections herein are based upon limited information provided by the airport owner about current O&M expenses. From this data "baseline" values of O&M charges for 1977 were estimated. The resultant baseline costs are presented in Table X.

In order to facilitate projection of future O&M expenses by category, a parameter was [illegible] that [illegible] close relationship to the future [illegible] classification of baseline [illegible] example, [illegible] maintenance costs are assumed [illegible] acquires the new property [illegible]

TABLE X

Baseline Estimates for O&M Expenses,
[illegible] W. Hooks Memorial Airport

Category	Annual Expense
Grounds Maintenance	[illegible]
Hangar Maintenance	[illegible]
Administration	[illegible]
Security	[illegible]
TOTAL	[illegible]

TABLE XI

Operation and Maintenance Expense [illegible]
Parameters, [illegible] W. Hooks Memorial Airport

O&M Category	Parameter
Grounds Maintenance	[illegible]
Hangar Maintenance	Number [illegible]
Administration	Number [illegible]
Security	Number [illegible]

[illegible]

TABLE [illegible]

[illegible]

Expense Category	Budget Year [illegible] 1982	1987	1997
Grounds Maintenance	$ 35,700	$ 97,400	$191,600
Hangar Maintenance	62,600	97,600	216,000
Administrative	68,600	107,000	238,300
Security	33,300	51,900	114,800
TOTAL	$200,200	$353,900	$760,700

Sources of annual operating revenue at Hooks include:

- T Hangar Rent
- Other Hangar Rent
- Administrative Space Rent
- Fuel Flowage Fees

As with O&M expenses, very little historical information of the above revenues is available with the exception of fuel flowage. The revenue projections in this part of the Master Plan are based upon information from the current airport owner and a reasonable estimation of projected rental fees from planned new construction under this Master Plan. Fuel flowage fees are assumed to be $.[illegible] per gallon.

Table XIII depicts revenue projections for the budget years ending in 1982, 1987, and 1997.

TABLE XIII

Operational Revenue Projections, D. W. Hooks Memorial Airport

Revenue Category	Budget Year Ending 1982	1987	1997
T Hangar Rent	$354,240	$462,000	$ 613,800
Other Hangar Rent	229,480	372,400	627,700
Administrative Space	76,500	93,500	125,500
Fuel Flowage Fees	51,600	72,000	110,000
TOTAL	$711,820	$999,900	$1,477,000

The combination of O&M expense and revenue projections provides an available net cash value. This comparison presents an indication of the fiscal soundness of the

airport and the amount of capital improvement funding that must come from other sources. Table XIV is a year-by-year summary of revenues and expenses. Note that in every year of the study revenues exceed expenses.

As indicated earlier in this report, the expense and revenue forecasts of Table XIV embody certain projected rate changes and significant increases in general aviation operations. The estimated cash flow would have to be reviewed periodically to verify underlying assumptions. Significant deviations between the values of this report and actual costs revenues might dictate a need for rate adjustments.

The primary sources of funding for airport improvements include municipal government funding, federal or state grants, and user related fees and rentals.

Municipal government funding is available from revenue or general obligation bonds, contributions from a locality's general tax fund, and possibly private contributions in the form of fixtures or real estate. As noted earlier in this section, no tax money for development at Hooks will be available. Also, no private contributions are anticipated. Accordingly, funds for capital development provided by the County would have to be general obligation or revenue bonds.

With respect to federal grants, the FAA administers its Airport Development Aid Program (ADAP) within the provisions of the Airport and Airways Development Act of 1970 as amended in 1976. The FAA allocates funds to

TABLE A17

Net Cash Analysis, [illegible] W. [illegible] Memorial Airport

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Operating Revenues										
T Hangar Rent	$ 165240	$ 202830	$ 250800	$ 300340	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Other Hangar Rent	103939	124727	164009	[illegible]	229480	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Administrative Space Rent	46195	51970	60744	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fuel Flowage Fees	36000	40500	42750	48000	[illegible]	[illegible]	60000	[illegible]	[illegible]	[illegible]
Total	$ 351374	$ 419997	$ 518303	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operation and Maintenance Expenses										
Grounds Maintenance	$ 14400	$ 16486	$ [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hangar Maintenance	31000	37479	45114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Administrative	35500	45756	52835	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Security	18250	22403	25585	29104	33300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	$ 99150	$ 122124	$ 154743	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Cash	$ 252224	$ 297873	$ 363560	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Operating Revenues										
T Hangar Rent	$ 480384	$ 483840	$ 502680	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Other Hangar Rent	396459	420487	494515	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Administrative Space Rent	96111	98781	101451	104121	106790	109460	[illegible]	[illegible]	[illegible]	[illegible]
Fuel Flowage Fees	75000	78750	82500	86250	90000	[illegible]	100800	[illegible]	[illegible]	[illegible]
Total	$1047954	$1081858	$1181146	$1196408	$1234103	$1285814	[illegible]	[illegible]	[illegible]	[illegible]
Operation and Maintenance Expenses										
Grounds Maintenance	$ 104219	$ 111515	$ 119321	[illegible]	$ 136610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hangar Maintenance	104401	111209	123712	[illegible]	141638	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Administrative	116643	126574	137724	148284	160828	174401	[illegible]	204089	[illegible]	[illegible]
Security	56164	60838	65890	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	$ 381427	$ 410636	$ 446647	$ 479681	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Cash	$ 666527	$ 671222	$ 734499	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

airports both on the basis of air carrier passengers enplaned and on a discretionary basis. Since Hooks Airport is not expected to develop air carrier service, only discretionary funding would be available from the federal government.

The maximum ADAP funding amount authorized by law for an airport such as Hooks is 80 percent of the eligible cost for projects funded in fiscal years (FY) 1979 and 1980. The obligational authority established for ADAP does not extend beyond 1980. For the purposes of this report, it is assumed that the federal Congress will extend the obligational authority of ADAP over the period of the Master Plan and that existing allocation formulas will be continued.

State funds are available through the Texas Airport Aid Program from grants offered by the Texas Aeronautics Commission (TAC). State grants must be matched by locally generated funds, with the maximum state contributions to any one single project currently being $75,000 per fiscal year. Due to long-term uncertainties associated with statewide priorities, a nominal amount of $5,000 per year in TAC grant funds was assumed to be available for construction at Hooks Airport for years in which capital improvements are planned.

A final category of funding is from fees paid by airport users. At Hooks these fees include hangar

rentals, administrative space rentals, and fuel flowage charges. These monies were discussed previously.

In combination with annual revenues, bond sales, and the $5,000 assumed state grant, different levels of federal funding were applied to eligible capital improvements in order to define the funding alternatives possible for Hooks. Beginning with the aforementioned maximum ADAP percentage allowed (80 percent) and working in 10 percent increments (70 percent federal funding, 60 percent, and so on) it was determined that at least 50 percent of the necessary funds for development at Hooks would have to be provided under ADAP. With any lower percentage, the debt service on the County issued bonds that would be necessary to cover the difference in required funds could not be met and capital improvements could not be accomplished.

Assuming the worst case, that is, only 50 percent federal funding, a bond issue in the neighborhood of $4,380,000 in 1980 would be required in Harris County. Federal grants of $3,764,000 and $981,000 in 1980 and 1985 respectively would be necessary in addition to the $5,000 in state grants already mentioned. After 1987, the net operating income is such that no additional grant funding is necessary to fund capital development. Naturally, in the event that a greater amount of ADAP money becomes available to Harris County, the bond requirement and corresponding debt service would be reduced.

Table XV through XIX show the estimated bond and grant commitments necessary with 80 percent, 70 percent, 60 percent, and 50 percent ADAP funding respectively.

TABLE XV

Bond Commitment Alternatives,
D. W. Hooks Memorial Airport

Percent of Eligible Capital Improvement Funds Provided by Federal ADAP Grant	Approximate Bond Amount Required
50	$4,380,000
60	3,600,000
70	2,900,000
80	2,100,000

Note: ADAP grant funding must provide at least 50 percent of eligible development money for an economically feasible capital improvement program.

TABLE XVI

ADAP Grant Funds Required with 50 Percent
Federal Funding of Eligible Capital Improvements

Year	ADAP Funds Required
1980	$3,763,750
1985	980,500

TABLE XVII

ADAP Grant Funds Required with 60 Percent
Federal Funding of Eligible Capital Improvements

Year	ADAP Funds Required
1980	$4,516,500
1985	1,176,600

TABLE VIII

ADAP Grant Funds Required with 70 Percent
Federal Funding of Eligible Capital Improvements

Year	ADAP Funds Required
1980	$5,629,250
1985	1,372,700

TABLE VIX

ADAP Grant Funds Required with 80 Percent
Federal Funding of Eligible Capital Improvements

Year	ADAP Funds Required
1980	$6,022,000
1985	1,568,800

Phase II: Environmental Impact Assessment
Report (EIAR)

The EIAR that I prepared as part of the Phase II portion of the Master Plan is Appendix B of this internship report. Basically, the EIAR incorporates the air and noise impact assessment analysis accomplished for Phase I in the format required by the FAA. Certain other environmental considerations (the impact of lighting and possible flood plain encroachment, for example) are included in the EIAR.

UPDATE OF THE MASTER PLAN FOR SANITARY SEWERAGE, NORTHSIDE SERVICE AREA, HOUSTON, TEXAS

In order to accomplish the second short-term objective of the internship, I was assigned to the Environmental Planning Team within TCB. Mr. William J. Moore, the head of the team, was assigned to be my immediate supervisor.

Nature of the Particular Assignment

TCB has been preparing Master Plans for the City of Houston's sanitary sewerage system since 1961. The plans are periodically updated to account for current trends and recent improvements to the system. The original Master Plan for the majority of the Northside Service Area (NSA) was developed in 1965 and had not been updated.

The scope of work for the total plan included the following tasks:

1. Evaluation of Alternatives for Conveying Flows From the Eleventh Street Lift Station Service Area
2. Establishment of a Data Base
3. Establishment of a Flow Projection Basis
4. Development of Flow Projections
5. Identification of Deficiencies
6. Development of Alternative Plans

Personnel from TCB had already completed Tasks 1 and 2 above before I arrived. Appendix D describes the

methodology that I used for Tasks 3 through 6 and gives the detailed results of my contribution to the Master Plan.

Development of Computer Program

In the Interim Report (Appendix D) I refer to the development of a computer program to aid in the preparation of the Master Plan, I wrote the program, entitled "SANSEW," to satisfy a long standing need of TCB. The supporting calculations for previous Master Plans had been done by hand. To give the reader an idea of the magnitude of the calculations involved, I estimate that approximately 5,000 computations are required for each year of the Northside Master Plan study. Since there were three year groups covered in the Master Plan (1983, 1990, and 2000) some 15,000 calculations were necessary. Assuming ten seconds per calculation around 40 manhours would be required to generate the data needed to complete the plan using only one set of flow factors. SANSEW performs the computations in five minutes. The high speed of the computer also allows the planners at TCB to evaluate a wider range of projected flow scenarios than was possible previously. For example, by changing only one card in the program deck, I examined by computer the projected flow that resulted from two sets of flow factors in my analysis of the Northside Sewer System.

The User's Manual that I wrote for SANSEW is Appendix E of this internship report. The User's Manual contains a detailed description of the program including among other information a listing and examples. Before leaving TCB to return to Texas A&M University, I briefed TCB personnel about SANSEW so that it could be used for similar future planning efforts undertaken by the company.

OTHER PROJECTS

During the internship I was asked to perform other assignments in addition to the two planning studies previously described. These projects are discussed below.

Participation with the Technical Chiefs of the Firm

During my first two weeks with TCB I worked with the Civil and Environmental Chiefs of the firm. Although I spent a significant amount of this time with Dr. Bishop while we planned the internship I also participated in the following activities:

1. Attended with Dr. Bishop meetings dealing with:
    a. A proposed expansion of the Sugarland, Texas Wastewater Treatment Plant.
    b. Interim progress reports of 1) a flood damage prediction study for Florence, Colorado and 2) a hydrologic study for the Lower Hartman Bottom, Lake Dardanelle, Arkansas.
    c. An Environmental Protection Agency hearing covering administration of federal funds for environmentally related projects. EPA has delegated authority for such administration to Texas.

2. Assisted in the technical review of the plans and specifications for the expansion of the Kerrville Water Treatment Plant.
3. Designed two of the structural steel pipe racks for the American Hoechst Corporation's high density polyethylene plant in Bayport, Texas.
4. Checked structural design for the steel frame supporting the conveyor belt system for sludge removal at the Sugarland Wastewater Treament Plant.

Additional Noise Impact Analyses

Besides the noise assessment I performed for David Wayne Hooks Memorial Airport I also performed similar analyses for Lakeside Airport in Harris County, Texas and for a proposed new airport in Texas City, Texas. Both of these evaluations used the FAA's INM and were incorporated into other Airport Master Plans submitted by TCB.

Sensitivity Analysis of the FAA's Integrated Noise Model

My immediate supervisor, Mr. William G. Griffin, during the airport planning project requested that I vary some of the parameters for the Lakeside noise analysis in order to determine the impact on the final results. The parameters I elected to modify included time of day, type

of aircraft, and aircraft [illegible] showed that [illegible] major changes in the final result [illegible] parameter modification caused [illegible] the acreage enclosed by the noise [illegible], only a few additional aircraft were allocated to night operation. I suspect that a higher percentage of night flights would create significant widening of the noise [illegible] the runway at Lakeside.

CONCLUDING REMARKS

The completion of my Doctor of Engineering internship marked the end of the most satisfying educational experience I have ever had. The enthusiastic support of the personnel in the firm especially Dr. Bishop and Messrs. Griffin and Moore certainly contributed to the successful completion of the internship. As an intern, TCB accorded me a unique position that I appreciated within the firm.

I feel confident that the internship satisfied the objectives of the College of Engineering. Both major projects I completed required me to perform at a highly technical level. In addition, I was certainly exposed to problems not normally associated with traditional design or analysis. For example, I relied heavily on the core finance courses in the Doctor of Engineering program when I prepared the financing plan for the Airport Master Plan. Also, a noise impact analysis with its extensive planning assumptions is definitely not a "traditional" Civil Engineering task.

With respect to the personal objectives I had set for the internship, I feel that I accomplished all of them with the exception of the one dealing with the attendance at meetings conducted by top management within the firm. I would have liked to have attended these meetings so that

I could see how a consulting firm receives its direction. Specifically, I was interested in getting some insight concerning why the firm channels its efforts into particular areas at the expense of others. I do not feel that my inability to attend these meetings detracted significantly from the internship.

A major plus for me with respect to my long term objectives was that I was given a rare opportunity to observe first hand how a consulting firm deals with government agencies. This experience will be a major benefit to me as an Air Force Civil Engineering officer. Frequently, the Air Force deals with consultants for a wide range of design services. In fact, this arrangement has received a high level of interest recently in the Air Force. I feel that my time with TCB has given me valuable insight into the operation of consulting engineering firms that few of my fellow officers have.

In conclusion, the professional internship required for the Doctor of Engineering degree was highly beneficial to me. I am quite certain that the experience has enhanced my progressive development as an Air Force Civil Engineering officer.

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4. U.S. Department of Transportation, Guidance Notebooks for the Environmental Assessment of Airport Development Projects, U.S. Department of Transportation, Washington, D.C., 1978.

5. U.S. Federal Aviation Administration, FAA Integrated Noise Model, Version 1, Basic User's Guide, U.S. Department of Transportation, Washington, D.C., 1978.

6. Airway Manual, Jeppesen & Co., Denver, Colorado, 1977.

7. U.S. Federal Aviation Administration, "Noise Standards: Aircraft Type and Air-worthiness Certification," Federal Aviation Regulation Part 36, 1969.

VITA

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Permanent Address:	6106 Yellowstone Drive Alexandria, Virginia, 22312
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The typists for this report were Louise Feder and Carolyn Sebek.

INTERN EXPERIENCE WITH

TURNER COLLIE & BRADEN INC.

VOLUME II

AN INTERNSHIP REPORT

by

Dennis Richard Topper

Submitted to the College of Engineering
of Texas A&M University
in partial fulfillment of the requirement for the degree of

DOCTOR OF ENGINEERING

August 1979

Major Subject: Civil Engineering

INTERN EXPERIENCE WITH

TURNER COLLIE & BRADEN INC.

VOLUME II

An Internship Report

by

Dennis Richard Topper

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August 1979

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APPENDIX A

Job No. 2280-010

INTERIM REPORT
SITE SELECTION
NORTHWESTERN HARRIS COUNTY
AIRPORT MASTER PLAN

March 1979

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Over the past fifteen years the number of general aviation aircraft in Harris County has nearly doubled.[1] As might be expected, this increase in aircraft, coupled with a corresponding increase in operations, has created considerable demand for expansion of airport facilities in the County. Unfortunately, neither municipally nor privately owned airports within the County have been able to respond rapidly enough to adequately handle the growth in general aviation air traffic. The resulting congestion has become a matter of concern to both the public and the private sectors.

A paradoxical factor in the heavy demand for general aviation facilities is the nationwide trend towards closure of privately owned public-use airfields.[2] Expansion of publicly owned airfields has somewhat dampened this trend, but not to a degree that prevents a decrease in the total capacity of ground aviation airports available for public use.

Reasons for private airport closures range from owners' personal concerns to pressures from local authorities or environmental interests. High property taxes also have tended to reduce

---

(1) Review and Refinement of the Regional Airport-Airspace System Plan Forecasts, H-GAC, June 1977.

(2) Potential Closure of Airports, U. S. Department of Transportation, Federal Aviation Administration, January 1978.

interest in privately owned public-use airfields. A national survey of 293 owners of private airports identified as being important in the National Airport System Plan (NASP) reveals that the most certain way to ensure continued operation of privately owned airports was conversion to public ownership.[3]

This report primarily addresses the need for publicly owned general aviation facilities within "northwestern" Harris County. Northwest Harris County is defined as that part of the County bounded to the south and west by U.S. Highway 290, to the east by Interstate Highway 45, and to the north by the county line along Spring Creek.

In view of 1) the aforementioned growth in general aviation in Harris County, 2) the requirement to better define the specific nature of the additional facilities needed to satisfy the projected aircraft demand in the northwest area of Harris County, and 3) the potential need for public participation in the ownership of general aviation facilities in this area, the Harris County Commissioners' Court made application for and was offered a grant from FAA for the purpose of developing an Airport Master Plan for a general aviation reliever airport located in the northwestern area of Harris County. The County formally accepted

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(3) Ibid.

the grant on September 5, 1977 and engaged Turner Collie & Braden Inc. to prepare the Master Plan.

This report is Phase I of a two-phase study. Phase I deals primarily with site selection, including analysis of demand, determination of facility requirements, engineering evaluation of Hooks, alternative site evaluation, and a preliminary environmental review.

Phase II of the study will cover the economic feasibility of public ownership of an airport in the northwestern part of Harris County and the recommended development program for such an airport. Specifically, Phase II will include preparation of an airport layout plan, land-use plan, aerial zoning plan, and airport access plan. An economic analysis and development schedule will also be submitted. Ultimately, Phases I and II will constitute a final master plan report suitable for submission to the FAA. A separate Environmental Impact Assessment Report (EIAR) will also be prepared.

The forecasted aircraft demand included in this section is premised upon the data reported in the June 1977 update of the regional general aviation forecast prepared for the Houston-Galveston Area Council (H-GAC) by the Engineers of the Southwest.[4] In the H-GAC forecast, the total number of aircraft predicted for Harris County is based upon population information for nine subareas of the County. Since the scope of this report is limited to northwestern Harris County, only aircraft from three of these subareas are included in the forecast total. These three subareas represent an area significantly larger than that defined as the northwestern Harris County study area. This region is considered to be the service area from which existing and future general aviation demand for the study area will originate. Many of the aircraft presently based in northwestern Harris County are owned by residents in the western part of the County. These aircraft are based in the northwest part of the County (primarily at Hooks) because of a general lack of facilities in the west. To varying degrees, this condition of demand and "spill over" into the northwestern study area is expected to continue in the future. In addition, aircraft totals have been adjusted to account for aircraft registered outside of a subarea but based

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[4] Review and Refinement of the Regional Airport-Airspace System Plan Forecasts, H-GAC, June 1977.

in it. For Harris County and each of the subareas, approximately 11 percent of all based aircraft are assumed to be registered outside the county.

Demand projections are presented for an overall time frame of 20 years and specifically for the planning years 1982, 1987, and 1997. The data for 1982 are intended to reflect the minimum level of aviation operations for which new facilities should be immediately designed and placed under construction. The 1987 forecast shows an increase in aviation activity that will generate additional facility requirements to be designed within two or three years with actual development in five to eight years. The reader is cautioned that the forecast for 1997 reflects assumptions about the economic base of the area and aviation technology which are reasonable at this time, but may not be valid in twenty years. Accordingly, the aircraft projections incorporated beyond 1987 should be used for long-term generalized developmental goals rather than to predict specific airport requirements.

Table 1 presents projections of general aviation aircraft to be based in Harris County in 1982, 1987, and 1997. Table 2 shows the projected numbers of based aircraft, by type, for the planned airport facility in northwestern Harris County for the same time periods.

TABLE 1 - BASED AIRCRAFT FORECAST, HARRIS COUNTY TOTAL

	Based Aircraft
1982	2,074
1987	2,402
1997	3,060

TABLE 2 - BASED AIRCRAFT FORECAST, NORTHWESTERN HARRIS COUNTY AIRPORT

	1982		1987(2)	1997(2)
	(1)	(2)		
Single Engine	231	252	260	265
Multi-Engine				
Piston	56	61	68	77
Turboprop	13	15	24	36
Turbojet	15	16	30	51
Rotorcraft	15	16	18	21
	330	360	400	450

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(1) Assumes Andrau Airport is still operational.

(2) Assumes Andrau Airport is not operational.

The reader will note two projections for 1982. The two alternative forecasts shown in Table 2 for 1982 reflect alternative assumptions regarding the future disposition of Andrau Airport. Although Andrau is not located in the study area, the airport accommodates general aviation demand which would spill over into the northwest area if the capacity at Andrau were not available.

Annual airport operations forecasts, by aircraft type, are also made for 1982, 1987, and 1997. These predictions are based upon estimates of operations[5] per aircraft as shown in Table 3. Table 3 assumes that itinerant operations are the same as based aircraft operations at some alternate field. Table 4 shows the estimated annual operations forecast by aircraft type thus derived.

No air carrier operations are included in the forecasts, since air carrier service is not expected to develop in northwestern Harris County due to the distance from downtown Houston and proximity to Houston Intercontinental Airport.

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[5] One aircraft operation is defined as either a take-off or a landing.

TABLE 3 - ANNUAL GENERAL AVIATION OPERATIONS PER AIRCRAFT
NORTHWESTERN HARRIS COUNTY

Aircraft Type	1982	1987	1997
Single Engine	525	525	525
Multi-Engine			
Piston	415	430	450
Turboprop	480	485	490
Turbojet	440	450	475
Rotorcraft	950	950	950

TABLE 4 - ANNUAL OPERATIONS FORECAST,
NORTHWESTERN HARRIS COUNTY AIRPORT

	1982		1987 (2)	1997 (2)
	(1)	(2)		
Single-engine	121,275	132,300	136,500	139,125
Multi-engine				
Piston	23,240	25,315	29,240	34,650
Turboprop	6,240	7,200	11,640	17,640
Turbojet	6,600	7,040	13,500	24,225
Rotorcraft	14,250	15,200	17,100	19,950
TOTAL	171,605	187,055	207,980	235,590

(1) Assumes Andrau Airport is still operational.

(2) Assumes Andrau Airport is not operational.

The previous section's projected aviation-demand results in the facilities' requirements described in this section for the proposed northwestern Harris County airport. The reader should note that where two projections of aircraft demand exist (the case of 1982 for Andrau Airport), the larger number is used in this analysis.

Landside Facilities

Landside facilities include hangars, automobile parking spaces, service areas, ground transportation access, and fire protection.

Table 5 reflects the estimated number of hangar spaces required. In this estimate, it is assumed that approximately two percent of the aircraft owners will elect to tie down their planes.

The airport will require automobile parking capacities as shown in Table 6.

A full-service maintenance facility of approximately [illegible] square feet would be required. The maintenance area sh[illegible] planned with room for expansion in future years as [illegible] of aircraft based at the airport increases. By [illegible] approximately 7,000 square feet and 9,000 squa[illegible] will be required.

Provision should also be made f[illegible] point in 1982 with addition of a[illegible]

AD-A106 373 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH F/G 13/2
INTERN EXPERIENCE WITH TURNER COLLIE AND BRADEN INC. AN INTERNS--ETC(U)
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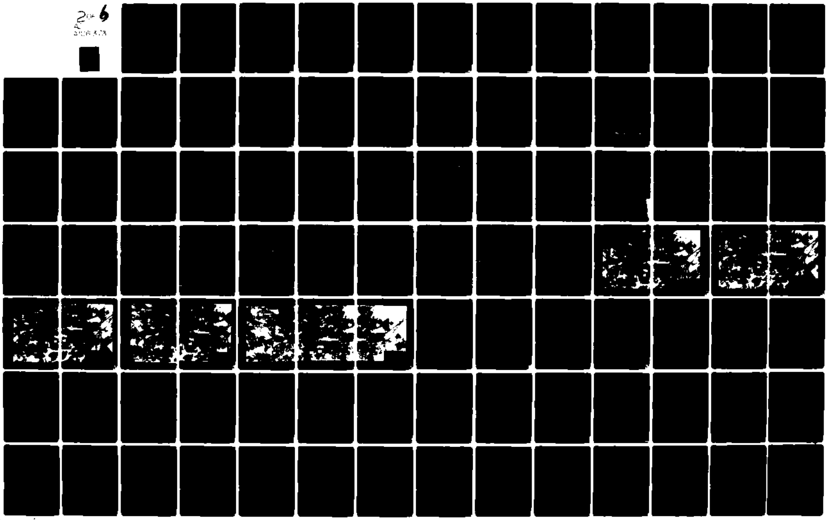

TABLE 5 - HANGAR SPACE REQUIREMENTS
NORTHWESTERN HARRIS COUNTY AIRPORT

	1982	1987	1997
Number of Required Hangar Spaces	355	390	440

TABLE 6 - AUTOMOBILE PARKING SPACE REQUIREMENTS
NORTHWESTERN HARRIS COUNTY AIRPORT

	1982	1987	1997
Total Number of Automobile Parking Spaces Required	240	270	300

The airport would need a small fire-protection facility of 700 square feet to house one vehicle.

Finally, a 2,500-square-foot restaurant is recommended for the proposed airport.

Airside Facilities

In order to meet the number of aircraft operations forecast, a dual-parallel runway system is recommended. A 4,000-foot runway would be necessary for most single-engine and twin-engine piston aircraft. This facility should be 75 feet wide and be structurally capable of handling aircraft gross weights to 12,500 pounds.

A parallel runway at least 6,000 feet long is also needed and should be designed to handle larger twin-engine piston aircraft as well as turboprop and turbojet aircraft. This runway should be 100 feet wide and able to sustain gross weights to 60,000 pounds.

Taxiways associated with both runways should be 40 feet wide. With respect to alignment, each runway should be oriented to a bearing of 350 degrees for takeoffs to the north and 170 degrees for takeoffs to the south.

Flexible asphaltic concrete pavement is acceptable for both runways; however, a rigid Portland cement concrete pavement should be considered for the 6,000-foot runway.

The longer runway should have sufficient navigational aids to allow for an instrument approach. An instrument landing system

(ILS) consisting of a localizer, glide slope facility, and marker beacon is required to satisfy instrument approach specifications.

A nonprecision approach should be provided for the 4,000-foot runway. Navigational aids associated with this runway include the following:

Very High Frequency Omnirange (VOR)
Distance Measuring Equipment (DME)
Visual Approach Slope Indicator (VASI)

Note that the DME requirement above is commonly satisfied by a Tactical Air Navigation System (TACAN). The combination of VOR and TACAN is called a VORTAC.

Lighting requirements for the airport include runway and taxiway edge lighting, a rotating beacon, a lighted wind indicator, and taxiway exit lights or signs. Additionally, a medium intensity approach lighting system with runway end identifier lights is required for the instrument approach runway.

TABLE 7 - RUNWAY AND TAXIWAY REQUIREMENTS
NORTHWESTERN HARRIS COUNTY AIRPORT

<u>Present Requirement</u>	
Alignment/Designation	35L/17R
Length	4,000 ft
Width	75 ft
Single Gear Design Load	12,500 lbs
Taxiway Width	40 ft
<u>By 1987 Additional Requirement</u>	
Alignment/Designation	35R/17L
Length	6,000 ft
Width	100 ft
Single Gear Design Load	60,000 lbs
Taxiway Width	40 ft

This section presents an inventory and evaluation of the existing facilities at David Wayne Hooks Memorial Airport. Included herein are descriptions of the operational capacity of Hooks, conditions of existing facilities, ground accessibility of the airport, property availability, required clearances, availability of utilities, soil conditions, and expansion potential.

Hooks is located near the intersection of Spring Cypress and Stuebner-Airline roads in northwestern Harris County. The airport facilities occupy approximately 460 acres of land out of a larger land tract which is owned by the airport's owner, Mr. Charles Hooks.

Currently, about 275 aircraft of various types are based at Hooks. Hangar spaces are available for nearly 90 percent of these aircraft with the remainder occupying tie-down spaces. Table 8 is an inventory, by type, of based aircraft.

The existing primary runway at Hooks is asphalt, 5,340 feet long and 110 feet wide. A secondary parallel runway, located 300 feet from the primary runway centerline, is 2,500 feet long and 40 feet wide. A parallel taxiway, 2,500 feet long and 30 feet wide, runs between the two runways. This taxiway is located 150 feet and 120 feet from the centerlines of the primary and secondary runways respectively. Both runways are aligned for approaches from the south at a 350 degree magnetic azimuth and

TABLE 8 - CURRENT BASED AIRCRAFT, HOOKS AIRPORT
NORTHWESTERN HARRIS COUNTY

Type	Number
Single Engine	210
Multi-Engine	
Piston	47
Turboprop	5
Turbojet	3
Rotorcraft	12
TOTAL	277

from the north at a 170 degree magnetic azimuth. In addition to the paved runway surfaces, Hooks also has a seaplane landing area that is 2,600 feet long and 100 feet wide. The seaplane approaches lie on the same magnetic azimuths as the paved runway.

The runway pavement is in good condition. Taxiway surfaces range from good to fair. Some new taxiway paving is in place west of the T-hangars; however, the remainder of the taxiway pavement is in fair condition with some severe rutting evident in areas of heavier traffic. Taxiway wearing surfaces, with the exception of the newer pavement noted above, are weathered and in need of a seal coating, overlay, or replacement. No strength testing was accomplished for the runways and taxiways, and no as-built drawings are available of the runway cross-sections that would allow determination of the load-carrying capacity of the pavement structure. The Federal Aviation Administration Master Record for the runway indicates an estimated single-wheel load capacity of 30,000 pounds for the primary runway and 4,000 pounds for the secondary runway. The 30,000-pound capacity for the 5,340-foot runway is somewhat questionable. A more detailed analysis of the pavement would have to be made prior to undertaking design for runway improvements.

The parking aprons at Hooks are in fair condition. The wearing surfaces are weathered and in need of a new seal coat or overlay to prevent further deterioration.

Runway lighting at Hooks is limited to low intensity edge lighting and runway end identifier lights. If the runway were to be upgraded, significant additional lighting would be required to meet minimum lighting specifications noted in the third section of this report.

The estimated annual capacity of the airport is shown in Table 9. The capacity calculation and forecast of the first section indicate that operations at Hooks will exceed the airport's capacity in the mid-1980's.

Landside facilities at Hooks are good. 162 T-hangars are available to the public along with some 36 other hangars. These facilities can house approximately 250 aircraft. In addition, tie-down space exists for about 60 aircraft. One hangar, leased by the U. S. Army and used for military aircraft, is located in the northwest section of the airport.

Air and auto refueling locations are present at Hooks. In addition, the airport has 4,700 square feet of pilots' lounge and restaurant which are in good condition. Two fixed-base operators provide full service maintenance capability and five flying schools operate from Hooks. Parking space for 340 automobiles is available.

The airport is accessible via Stuebner-Airline Road which is a two-lane asphalt road in good condition and maintained by Harris County. The road runs north to the airport from Houston before

TABLE 9 - CAPACITY ANALYSIS, HOOKS AIRPORT
NORTHWESTERN HARRIS COUNTY

	Number of Operations
Annual Capacity	201,600
Peak Daily Capacity	1,100
Peak Hourly Capacity	95

assuming a westerly course into Tomball. Widening of this road proximate to the airport would have to be considered by the 1987 time frame of this study in order to accommodate the expected increase in auto traffic. Since the road forms a boundary to the north and east of Hooks, expansion of the airport in these directions is limited unless the road is relocated.

All utilities, including electricity, water, and natural gas, are provided at Hooks. Sanitary sewage is disposed through a septic system and drain field.

The land near Hooks is mostly flat grassland with one small area of trees on the airport property northwest of the primary runway. No line-of-sight limitations exist to the south, east, or west. A line of trees runs east-west about two miles off the north end of the runway.

Table 10 reflects the soil characteristics proximate to Hooks Airport. The predominant soil type is Wockley loam which consists mainly of low compressibility clay. Small pockets of Gessner loam are located on either side of the seaplane landing area and due west of the primary runway. A third soil type, Segno loam, is prevalent to the northwest of the airport.

TABLE 10 - SOIL TYPES AND CHARACTERISTICS, HOOKS AIRPORT
NORTHWESTERN HARRIS COUNTY

Soil Type	Unified Soil Classification	Liquid Limit Range	Plasticity Index Range
Gessner Loam	CL	17-40	4-20
Segno Loam	CL	20-40	8-26
Wockley Loam	CL	18-35	4-17

Source: Soil Survey of Harris County, Texas, USDA, Soil Conservation Service, August 1976.

All three soil types exhibit low shrink/swell potential. Also, the Segno and Gessner loams generally exhibit low shear strength. The Wockley loam has moderate shear strength. The Wockley and Gessner soils present high risk of corrosion to uncoated steel. These three soil types, while not ideal, do not present significant problems to construction of the lightly loaded facilities normally associated with a small general aviation airport such as Hooks.

The Hooks site has a high groundwater table located from zero to two feet below the surface. The flood potential is very low to nonexistent.[6]

As noted earlier in this section, in order to meet the potential demand for Northwestern Harris County, Hooks would require extensive upgrading and expansion. This development is technically feasible. Another runway parallel to the existing runway and 6,000 feet in length is needed by 1985 to meet the forecasted demand. The site would also require 105 additional hangar spaces by 1982, 35 more spaces by 1987, and 50 more spaces by 1997. The navigation aids and improved runway lighting equipment noted in Section 2 would also have to be installed. Additional land acquisition and easements for clear zones required to expand Hooks are shown in Table 11.

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(6) Soil Survey of Harris County, Texas, USDA, Soil Conservation Service, August 1976.

TABLE 11 - LAND ACQUISITIONS, HOOKS AIRPORT
NORTHWESTERN HARRIS COUNTY

Required for Airport Facilities by 1985	Acres
Existing Hooks Airport Property	460
Property Held by other Owners	160
Easements for Clear Zones by 1985	
Hooks Property	50
Others	70

In this section, eight alternative locations for a County airport in northwestern Harris County are identified and evaluated in order to provide comparative data relative to these sites. The goal of site evaluation is to establish the optimum location for the airport. Criteria used in the evaluation process include:

1. Location within the study area. One important consideration in site selection is a potential site's proximity to the users of the airport.

2. Location in relation to other local airports. A site should be selected so that the future aircraft operations will not encroach upon the airspace of other airports.

3. Access requirements. Sufficient roadways should be near the site to allow ready accessibility to airport users.

4. Noise considerations. The airport site should be located in an area not proximate to residences, schools, churches, or other entities that would be sensitive to the noise that will be generated by aircraft operations.

5. Potential conflicts with existing utilities, railroad, and roadway rights-of-way. When such conflicts exist, considerable additional expense is usually involved in the development of the airport since the rights-of-way generally require relocation.

6. Availability of utilities. As with "5" above, considerable expense can be saved during airport development if utilities already exist near the site.

7. Consideration of potential airport site configuration. The airport site should be adequate to accommodate the development described in the section of this report entitled "Determination of Facility Requirements."

The sites evaluated are depicted in Exhibit 3 and are discussed individually in the following paragraphs. Table 12 is a quantitative summary of the site selection analysis.

TABLE 12 - SITE SELECTION ANALYSIS
NORTHWESTERN HARRIS COUNTY AIRPORT MASTER PLAN

	Airport Sites							
	1	2	3	4	5	6	7	8
Criteria								
Location within study area	4	4	4	4	5	3	3	4
Location in relation to other airports	5	4	4	5	4	5	5	2
Access requirements	5	4	4	4	5	3	3	4
Noise considerations	4	4	5	5	2	5	5	5
Potential conflicts with existing utilities, railroad, and roadway rights-of-way	4	4	3	3	2	2	2	3
Availability of utilities	4	5	3	3	5	2	2	3
Consideration of potential airport site configuration	3	5	4	2	2	2	2	4
TOTAL	29	30	27	26	25	22	22	25

1 = Poor

5 = Excellent

Site 1

This location lies about thirty miles from Houston directly off the northwest freeway (U. S. Highway 290) which provides a good noise buffer and ready accessibility. The site is bordered on the north, west, and east by undeveloped land. A pond is located in the southwestern corner of the site. No conflicts involving obstructions, rights-of-way, or clearances are evident at Site 1. Approximately 10 entities own property within the confines of the site. Roads bound the site on three sides. Utilities are readily available.

Site 2

Hooks airport is centrally located within the study area for this report. The site is adjacent to undeveloped farm lands to the north, east, and west. Access to the airport is via Stuebner Airline Road which bounds the airport to the east and northeast. Land for expansion of existing facilities is available to the west and south. Noise buffers in the form of undeveloped land exist for the site. Adequate utilities are available at Hooks. Pipelines crisscross the site to the south, but they would not interfere with possible facility expansion. Hooks is already a general aviation airport, so only the addition of a 6,000-foot parallel runway with its associated support equipment would be required.

Site 3

This property, like Hooks, is centrally located within the study area. Pipelines cross the property, which is predominantly undeveloped. Creeks can be found to the north and south. Elevation increases gradually by 20 feet when moving from south to north across the site. A pond is located in the eastern quadrant. Site 3 is bounded by West Montgomery Road to the east and Spring Cypress Road to the south. This arrangement would provide easy accessibility to the airport.

Site 4

Located on the northwestern fringe of the study area, Site 4 lies south of Waller Tomball Road and north of Schill Road. Both roads could provide access to the airport. Site 4 is crisscrossed by pipelines and traversed by a power line. In addition, utilities would be difficult to obtain due to the remote location and the lack of development in the area.

Site 5

Weiser Airport is conveniently located comparatively close to the Houston city limits (13 miles) and is easily accessible via the northwest freeway (U. S. Highway 290). The locale proximate to the site is highly developed. For example, Weiser is very near two schools to the west and bounded by a subdivision to the south. Accordingly, the impact of noise in the area,

should operations at Weiser be increased, would be significant. The development of schools, housing, and business at the boundaries of the airport also limit the ability of Weiser to expand to meet the anticipated facilities' requirements over the period of this study.

Site 6

The site consists mainly of undeveloped land and is located at the northwestern boundary of the study area. Although roads surround the area, access would still be difficult due to the remoteness of the property from a major highway. A power line crosses the property. Topography is not conducive to airport development since there is a fairly rapid 25-foot increase in elevation when moving from the southeastern quadrant of the site to the northwestern quadrant. The elevation change makes the area unsuitable for runway construction without extensive earth work. Utilities are not readily available.

Site 7

The property is adjacent to Site 6. As with the previous site, the property is mainly undeveloped land and remotely located in comparison to the suitable alternative airport locations. A cemetary lies in the northwestern quadrant; a power line crosses the property; and utilities are not readily

available. There is a 35-foot increase in elevation when moving form southeast to northwest across the site. Several sludge pits and a disposal well are on the site.

Site 8

Some interference with the airspace at Houston Intercontinental Airport would result from the use of this site. Woods present at the northern third of the property might be obstructions. The area is fairly close to Houston (12 miles) and accessible via Stuebner-Airline Road. Power lines crisscross Site 8. Minimal development is evident, but utilities would be available due to proximity to Houston. Oil wells with associated pipelines exist at the site. These wells could present problems with respect to land acquisition.

Summary

Considering the merits of each alternative site, Hooks Airport is recommended as the most favorable location for a general aviation airport in northwestern Harris County. Hooks itself is a one-owner facility with capacity for expansion through acquisition of adjacent lands. The site is readily accessible, if somewhat remote, to the Houston city limits. The site is almost completely surrounded by undeveloped land which minimizes potential noise impacts. Utilities are already available at Hooks. Topography at Hooks is flat, which is ideal for runway construction.

Finally, as an existing airport, Hooks possesses inherent advantages that a new location would not. Specifically, Hooks has airspace rights that would have to be obtained at a new airport. Persons living near Hooks are more acclimated to the noise associated with general aviation aircraft and would be less likely to object to continued operations at Hooks than would residents living or working near a new aviation facility.

Second and third alternatives in the form of sites 1 and 3 are available for consideration if acquisition of the primary site is either prohibitively expensive or unacceptable to local interests for environmental or other reasons. These alternate sites could be considered in turn if significant problems of such a nature are encountered with the primary site.

This section concentrates on the impact of noise and air quality in the area resulting from facilities expansion at Hooks Airport to accommodate the forecasted aircraft demand for northwestern Harris County. This preliminary environmental evaluation also includes an archeological assessment of the Hooks property. Phase II of this study will include an environmental assessment in approved FAA format.

Noise Impact

The purpose of the noise impact analysis is to identify noise-sensitive areas around the airport. The January 1978 edition of the FAA's Integrated Noise Model (INM) was used to obtain noise contour data for the anticipated mix of operations for 1978, 1982, 1986, 1987, and 1997. A description of the FAA INM and of the Ldn (Day-Night Sound Level) units used in the following exhibits is presented in Appendix A.

Noise impact results are also reported for 1986. 1986 is the year at which Hooks is expected to reach its operational capacity if no new runway is built. Thus, the 1986 noise contour presents the "do nothing" alternative that can be used to compare the impacts of noise both with and without the second parallel runway proposed for completion by 1987.

Guidelines for determining land-use requirements for different levels of noise were obtained from the FAA's manual

entitled Airport Land-Use Compatibility Planning, AC 150/5050-6, December 1977.

Exhibits 4 through 8 depict the noise contours for the northwestern Harris County airport. Noise levels determined from the analysis represent the mix of general aviation aircraft types forecast for Hooks airport. Prevailing wind data and aircraft operational characteristics were used to predict runway usage and to develop sound energy levels. Estimated flight tracks used in conjunction with the INM are in Appendix A.

The contours plotted are the boundaries of all areas exposed to noise levels equal to or greater than 65 and 75 Ldn. A 65 Ldn level is approximately equivalent to the noise intensity which might be expected in a noisy urban environment. The 75 Ldn noise level is considered clearly unacceptable with respect to environmental impact for normally constructed residential or similar noise sensitive land uses. A 75 Ldn level is equivalent to the noise encountered downtown in a major metropolis. Tables 13 and 14 present a more detailed description of noise impacts with respect to land use.

Examination of Exhibit 4 shows that the existing condition (1978) noise contours are almost totally confined to the airport boundaries.

Increased operations for 1982 cause a noise envelope (Exhibit 5) that is somewhat larger than 1978. The 65 Ldn contour

TABLE 13
LAND USE COMPATIBILITY PLANNING – AIRPORT NOISE
NORTHWESTERN HARRIS COUNTY AIRPORT

LAND USE GUIDANCE CHART I: AIRPORT NOISE INTERPOLATION

LAND USE GUIDANCE ZONES (LUG)	NOISE EXPOSURE CLASS	INPUTS: AIRCRAFT NOISE ESTIMATING METHODOLOGIES				HUD NOISE ASSESSMENT GUIDELINES	SUGGESTED NOISE CONTROLS
		L_{dn} DAY-NIGHT AVG SOUND LEVEL	NEF NOISE EXPOSURE FORECAST	CNR COMPOSITE NOISE RATING	CNEL COMMUNITY NOISE EQUIVALENT LEVEL		
A	MINIMAL EXPOSURE	0 TO 55	0 TO 20	0 TO 90	0 TO 55	"CLEARLY ACCEPTABLE"	NORMALLY REQUIRES NO SPECIAL CONSIDERATIONS
B	MODERATE EXPOSURE	55 TO 65	20 TO 30	90 TO 100	55 TO 65	"NORMALLY ACCEPTABLE"	LAND USE CONTROLS SHOULD BE CONSIDERED
C	SIGNIFICANT EXPOSURE	65 TO 75	30 TO 40	100 TO 115	65 TO 75	"NORMALLY UNACCEPTABLE"	NOISE EASEMENTS, LAND USE, AND OTHER COMPATIBILITY CONTROLS RECOMMENDED
D	SEVERE EXPOSURE	75 & HIGHER	40 & HIGHER	115 & HIGHER	75 & HIGHER	"CLEARLY UNACCEPTABLE"	CONTAINMENT WITHIN AIRPORT BOUNDARY OR USE OF POSITIVE COMPATIBILITY CONTROLS RECOMMENDED

TABLE 14
LAND USE COMPATIBILITY PLANNING – LAND USE NOISE SENSITIVITY
NORTHWESTERN HARRIS COUNTY AIRPORT

LAND USE GUIDANCE CHART II: LAND USE NOISE SENSITIVITY INTERPOLATION

LAND USE SLUCM NO	LAND USE NAME	LUG ZONE[1] SUGGESTED	LUG ZONE[1] STUDY
10	Residential	A B	
11	Household units		
11.11	Single units - detached	A	
11.12	Single units - semiattached	A	
11.13	Single units - attached row	B	
11.21	Two units - side by side	A	
11.22	Two units - one above the other	A	
11.31	Apartments - walk up	B	
11.32	Apartments - elevator	B C	
12	Group quarters	A B	
13	Residential hotels	B	
14	Mobile home parks or courts	A	
15	Transient lodgings	C	
19	Other residential	A C	
20	Manufacturing [2]	C D	
21	Food and kindred products manufacturing	C D	
22	Textile mill products manufacturing	C D	
23	Apparel and other finished products made from fabrics, leather, and similar materials manufacturing	C D	
24	Lumber and wood products (except furniture) manufacturing	C D	
25	Furniture and fixtures manufacturing	C D	
26	Paper and allied products manufacturing	C D	
27	Printing, publishing, and allied industries	C D	
28	Chemicals and allied products manufacturing	C D	
29	Petroleum refining and related industries [3]	C D	
30	Manufacturing (continued) [2]		
31	Rubber and miscellaneous plastic products manufacturing	C	
32	Stone, clay, and glass products manufacturing	C D	
33	Primary metal industries	C	
34	Fabricated metal products manufacturing	C	
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks manufacturing	B	
39	Miscellaneous manufacturing	C D	
40	Transportation, communication, and utilities [4]		
41	Railroad, rapid rail transit, and street railway transportation	D	
42	Motor vehicle transportation	D	
43	Aircraft transportation	D	
44	Marine craft transportation	D	
45	Highway and street right-of-way	D	
46	Automobile parking	D	
47	Communication	A D	
48	Utilities	D	
49	Other transportation, communication and utilities	A D	
50	Trade [4]		
51	Wholesale trade	C D	
52	Retail trade - building materials, hardware, and farm equipment	C	
53	Retail trade - general merchandise	C	
54	Retail trade - food	C	
55	Retail trade - automotive, marine craft, aircraft and accessories	C	
56	Retail trade - apparel and accessories	C	
57	Retail trade - furniture, home furnishings, and equipment	C	
58	Retail trade - eating and drinking	C D	
59	Other retail trade		
60	Services [4]		
61	Finance, insurance, and real estate services	B	
62	Personal services	B	
63	Business services	B	
64	Repair services	C	
65	Professional services	B C	
66	Contract construction services	C	
67	Governmental services	B	
68	Educational services	A B	
69	Miscellaneous services	A C	
70	Cultural, entertainment, and recreational		
71	Cultural activities and nature exhibitions	A	
72	Public assembly	A	
73	Amusements	C	
74	Recreational activities [5]	B C	
75	Resorts and group camps	A	
76	Parks	A C	
79	Other cultural, entertainment, and recreational [5]	A B	
80	Resource production and extraction		
81	Agriculture	C D	
82	Agricultural related activities	C D	
83	Forestry activities and related services	D	
84	Fishing activities and related services	D	
85	Mining activities and related services	C	
89	Other resource production and extraction	C D	
90	Undeveloped land and water areas		
91	Undeveloped and unused land area (excluding noncommercial forest development)	D	
92	Noncommercial forest development	D	
93	Water areas	A D	
94	Vacant floor area	A D	
95	Under construction	A D	
99	Other undeveloped land and water areas	A D	

1 REFER TO LAND USE GUIDANCE CHART I, PAGE 12
2 ZONE C SUGGESTED MAXIMUM EXCEPT WHERE EXCEEDED BY SELF GENERATED NOISE
3 ZONE D FOR NOISE PURPOSES, OBSERVE NORMAL HAZARD PRECAUTIONS
4 IF ACTIVITY IS NOT IN SUBSTANTIAL AIR CONDITIONED BUILDING GO TO NEXT HIGHER ZONE
5 REQUIREMENTS LIKELY TO VARY (INDIVIDUAL APPRAISAL RECOMMENDED)

SLUCM STANDARD LAND USE CODING MANUAL, SEE PARAGRAPH 2.

extends off the southern airport boundary about 1,600 feet and off the northern boundary 900 feet. To the north and south the overlap is into undeveloped farmland. There is no area subjected to a noise level of 75 Ldn or higher in 1982.

A 75 Ldn contour appears for the 1986 "do nothing" alternative due to the increased number of operations. This contour is within the existing airport boundaries while the 65 Ldn contour extends outside airport property by 3,600 feet to the south and 1,900 feet to the north. As noted previously, the 1986 case is developed from the anticipated mix of aircraft that will exist if no improvements to Hooks are made and if the airport reaches capacity level operations as expected by 1986.

In 1987, the addition of a parallel runway, coupled with increased operations, causes a significant widening and lengthening of the 65 Ldn contour. Although the northernmost portion of the contour stays within 700 feet of the property line for Hooks, the southernmost contour lies some 7,200 feet outside the property line. The land inside the contour presently consists mainly of undeveloped farmland; however, easements or land acquisition will be necessary to prevent encroachment into the noise-sensitive area of the runway by residential, business, or recreational development in the future. The 75 Ldn contour runs 300 feet to the south of the existing airport boundary, while to the north the contour stays inside the current property

line. The 75 Ldn contour remains within the expected airport boundaries.

Exhibit 8 presents the 1997 noise situation. The 65 Ldn contour has again expanded and widened. The southernmost extremity of the contour extends past Spring Cypress Road, about 8,000 feet from the end of the existing runway. To the north, the 65 Ldn contour extends 1,800 feet off the airport site. The 75 Ldn contour extends 3,500 feet to the south of the airport boundary, but stays inside the property line to the north.

The environmental impact of noise is lessened when higher noise exposure levels are confined to the airport boundaries. Land-use easements, or acquisition of all area subject to 75 Ldn or higher, might be advisable to reduce noise impact on areas outside the airport bounds.

No schools or churches currently exist within any of the contours developed. However, a few existing residences are included within the 1986, 1987, and 1997 65 Ldn contours. Insofar as possible, homeowners in the area should be notified of their location within a a potentially noisy environment. Some acoustical insulation may be needed for these homes, as well as noise abatement procedures for aircraft using Hooks. With proper planning during the initial stages of development, notification to prospective homeowners of the possible noise

impacts on residential areas, and appropriate noise abatement procedures by aircraft, the deleterious effects of noise can be minimized. Another consideration in the evaluation of potential noise impacts near Hooks is that the noise contours generated by the INM represent maximal noise levels to be expected if present-day aircraft types are flown from Hooks over the period of this study. In order to meet federal regulations with regard to noise, future aircraft will be required to be quieter. Thus, the contours shown herein likely overestimate the future noise impact to a certain degree. Table 15 shows acreage enclosed by various noise contours throughout the planning period.

Air Quality

The impact on surrounding air quality of the increased operations at Hooks will not be significant with the exception of air pollution that would result from construction of a new runway. Impacts on air quality from construction can be alleviated by following guidelines set forth in FAA Advisory Circular 150/5370-7, "Airport Construction Controls to Prevent Air and Water Pollution."

Data shown in Table 16 compare the impacts from the proposed improvements to the "Ambient Air Quality and National Air Quality Standards".(7) In fact, review of the data demonstrates the

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(7)Code of Federal Regulations: "Protection of Environment," 40 CFR Part 50 (Washington, D. C., July 1, 1975).

TABLE 15 - SUMMARY OF AREA ENCLOSED BY NOISE CONTOURS
D. W. HOOKS MEMORIAL AIRPORT

Year	Acres Enclosed 65 Ldn	Acres Enclosed 75 Ldn
1978	102	0
1982	173	0
1986	275	32
1987	602	57
1997	806	77

minimal effect of Hooks' aircraft on the surrounding air quality. The technique used to derive Table 16 is described in Appendix B.

Although increased surface traffic would be expected in the immediate vicinity of Hooks airport over the periods of this report, the resulting change in air quality on an areawide basis will not be significant. Presumably, the majority of persons basing aircraft at Hooks are already operating their private vehicles inside the study area. The incremental impact on air quality of these persons driving to Hooks to fly is considered negligible in comparison to normal daily driving within the study area.

Archeological Assessment

Dr. Frank Hole of the Rice University Department of Anthropology, under contract to Turner Collie & Braden Inc., conducted a survey of the Hooks site to determine the presence of any objects of historical, architectural, archeological, or cultural significance. Dr. Hole's investigation revealed that a sweetgum tree grove located northwest of the existing runway may have considerable historical importance. Dr. Hole believes the grove to be an overnight wagon train campsite for travelors in the nineteenth century. In addition, Sam Houston and his army may have camped at the grove on the way to San Jacinto. In any event, the development of Hooks Airport recommended in this report will be

planned to preserve the sweetgum grove. No other sites of historical, archeological, or cultural significance will be affected by expansion at Hooks. Dr. Hole's report is Appendix C hereto.

This report, Phase I of a two phase study to determine the need for a basic transport airport in northwestern Harris County, has provided the following information:

- A forecast of the aircraft demand for 1982, 1987, and 1997. In each year group, the study predicts a significant, continuing trend towards increased general aviation operations.

- An outline of facility requirements associated with a publically-owned airport in this area. A dual-parallel runway system with associated support facilities is recommended.

- An engineering evaluation of David Wayne Hooks Memorial Airport. Hooks is generally in good condition with the main requirement being the addition of a 6,000-foot parallel runway.

- Review of several potential sites for the airport. Hooks airport is recommended as the best location in northwest Harris County.

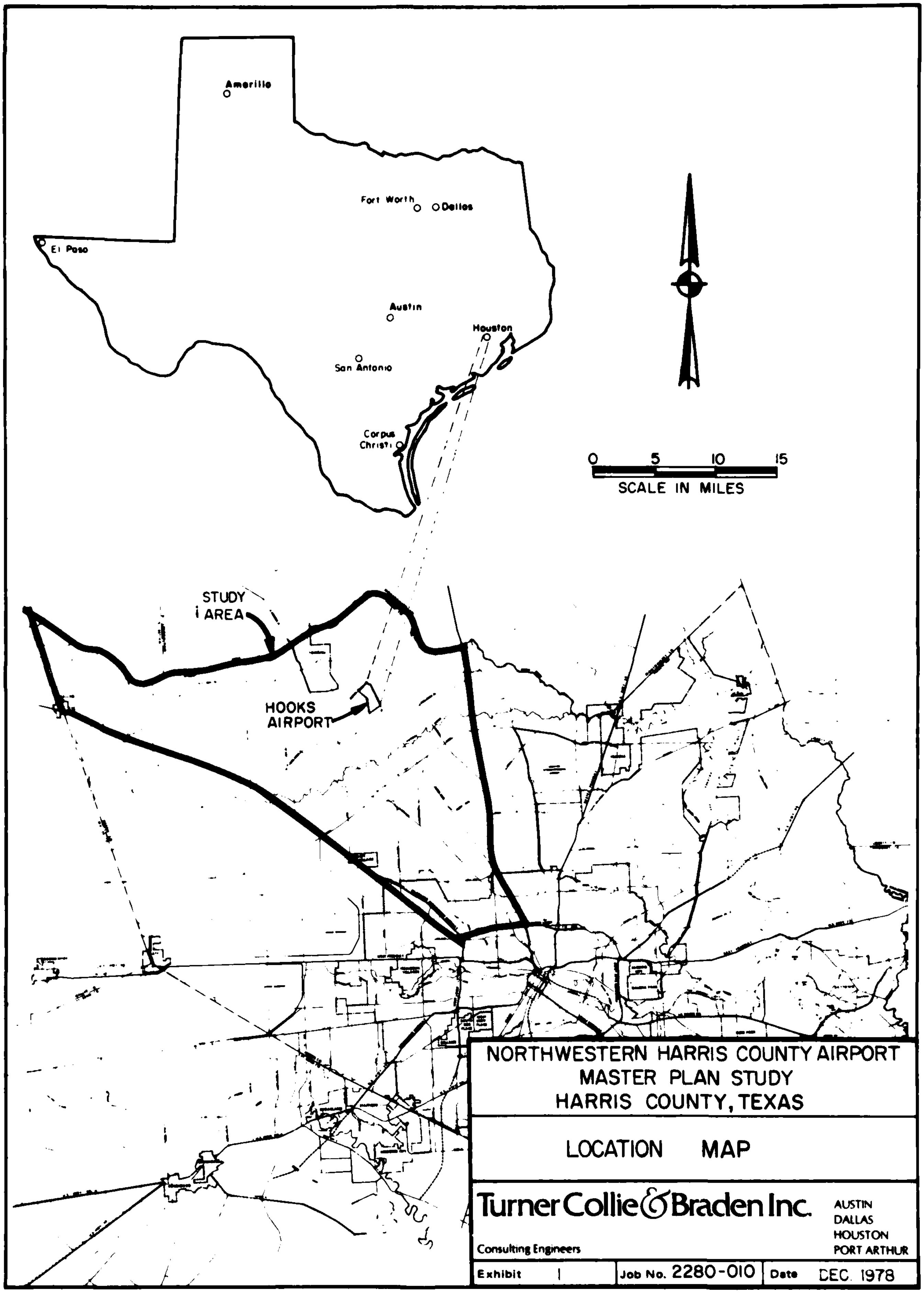
- A preliminary environmental review and evaluation of Hooks Airport as the recommended site for the publically-owned airport. The major environmental impacts associated with Hooks Airport results from aircraft noise. Noise impacts from the airport, while significant, encroach on only a very few residences. With proper planning, noise affects can be minimized.

In conclusion, Hooks Airport appears to be both a technically and environmentally sound choice for a publically owned airport in northwestern Harris County. However, public acquisition of Hooks is not recommended at this time. Hooks is a relatively stable operation with minimal developmental pressures from surrounding land owners. Additionally, because of the airport's configuration, the addition of a parallel runway would dictate a substantial land

acquisition which would tend to make economic feasibility difficult to achieve. It is recommended that the situation at Hooks be monitored in the future and, if changes occur which would indicate a significant increase in pressures toward closure of Hooks, public acquisition be reconsidered.

Phase II of this report to be completed in the near future will present the final airport plans in the framework of an "Airport Master Plan" in accordance with FAA Advisory Circular 150/5070-6 and "Instructions for Processing Airport Development Actions Affecting the Environment" (FAA Order 5020.2B.) In addition, Phase II will include a Development Schedule and Economic Feasibility and Financing Plan.

EXHIBITS

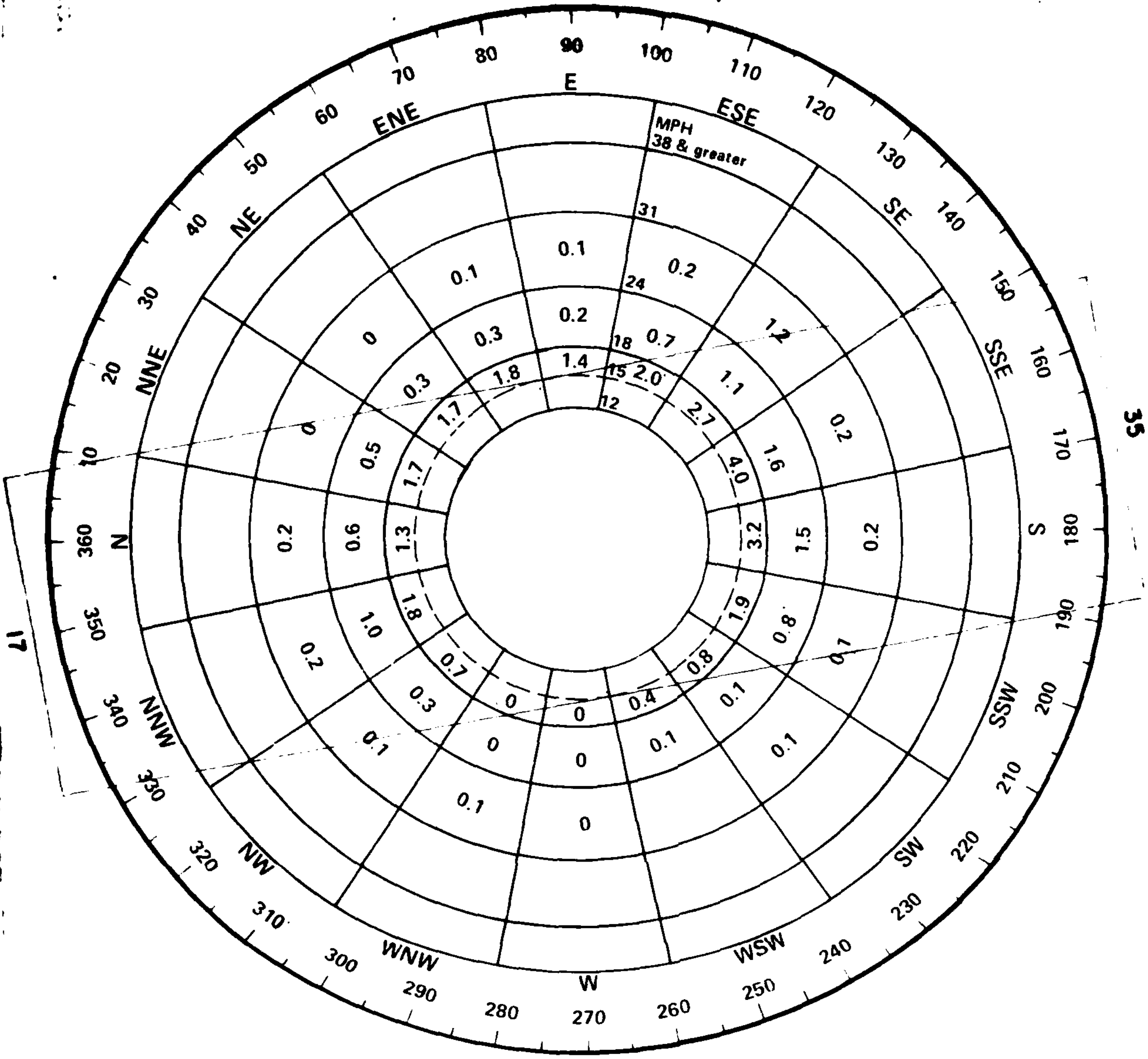


NORTHWESTERN HARRIS COUNTY AIRPORT
MASTER PLAN STUDY
HARRIS COUNTY, TEXAS

LOCATION MAP

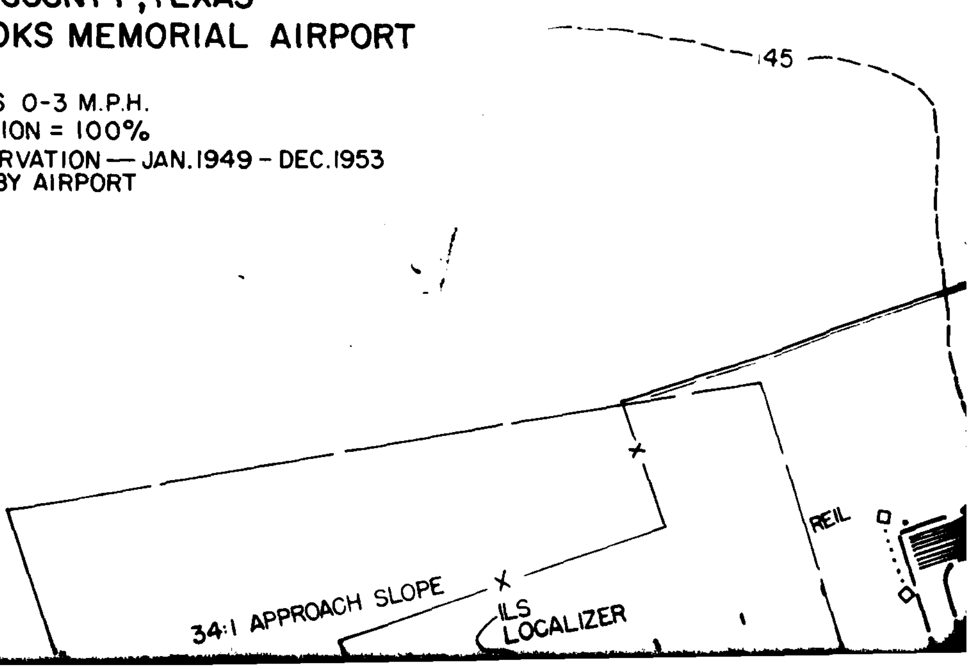
Turner Collie & Braden Inc.
Consulting Engineers
AUSTIN
DALLAS
HOUSTON
PORT ARTHUR

Exhibit 1	Job No. 2280-010	Date DEC. 1978

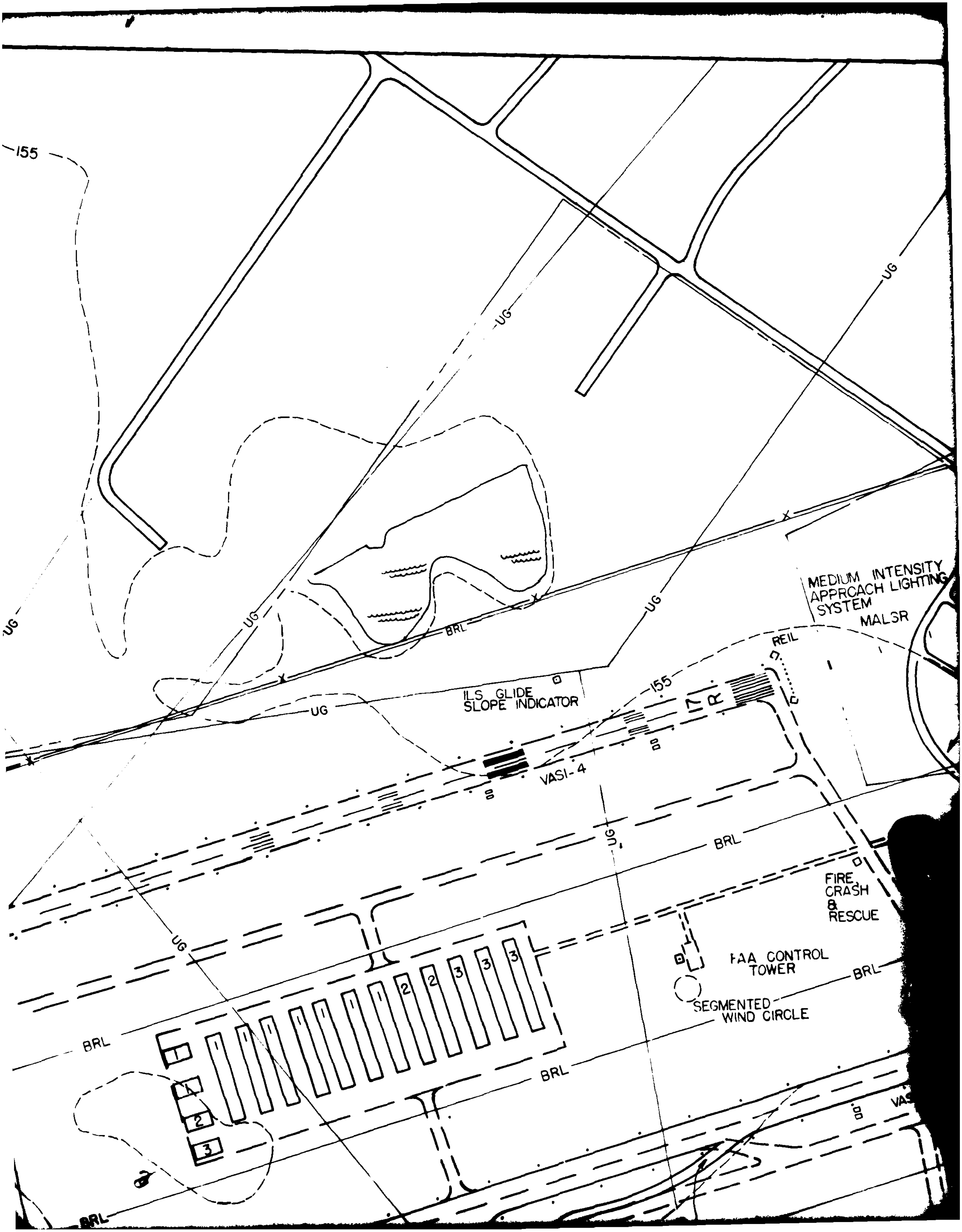


WIND ROSE
HARRIS COUNTY, TEXAS
DAVID WAYNE HOOKS MEMORIAL AIRPORT

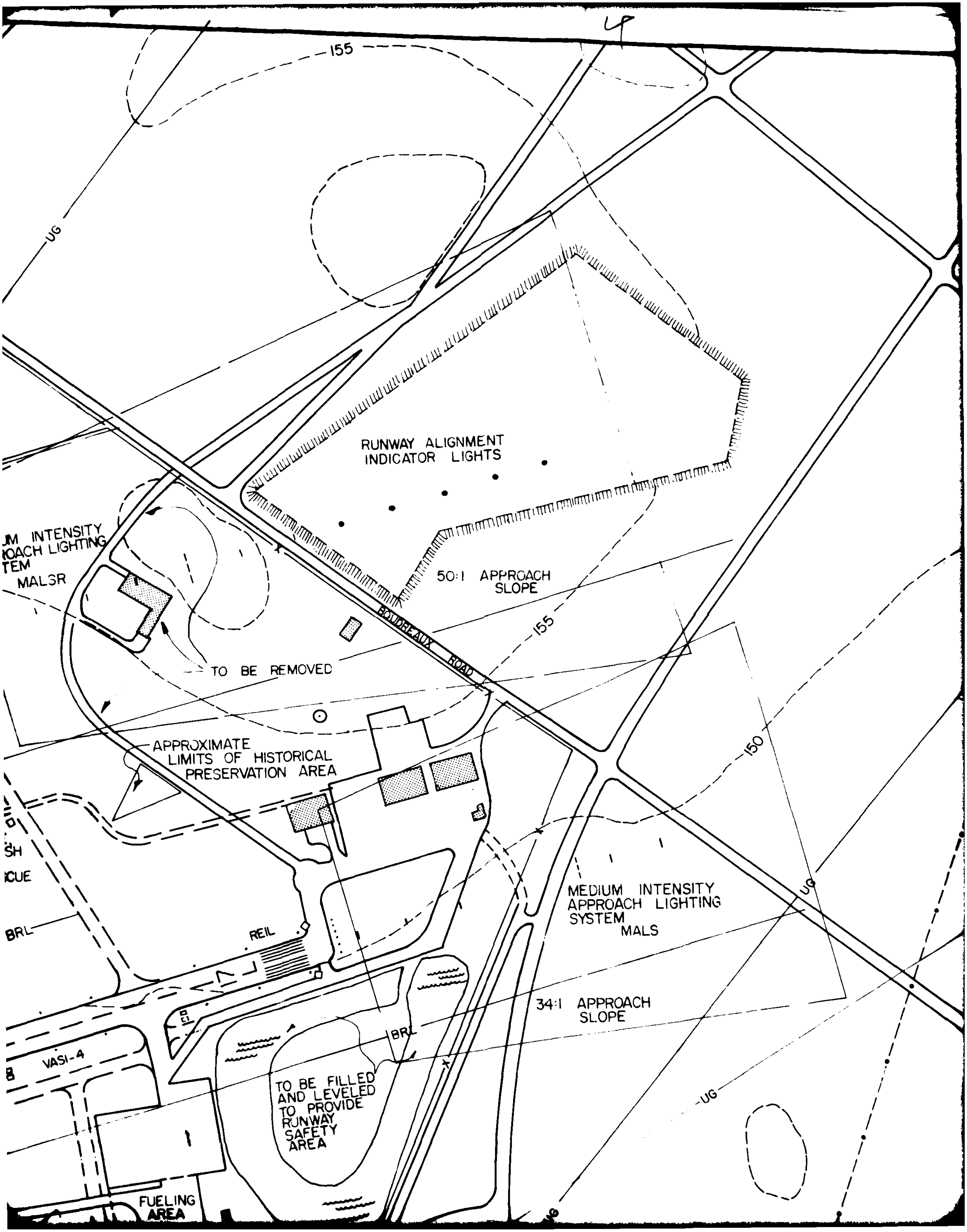
Δ 4.3% — CALMS 0-3 M.P.H.
TOTAL OBSERVATION = 100%
PERIOD OF OBSERVATION — JAN. 1949 - DEC. 1953
W.P. HOBBY AIRPORT



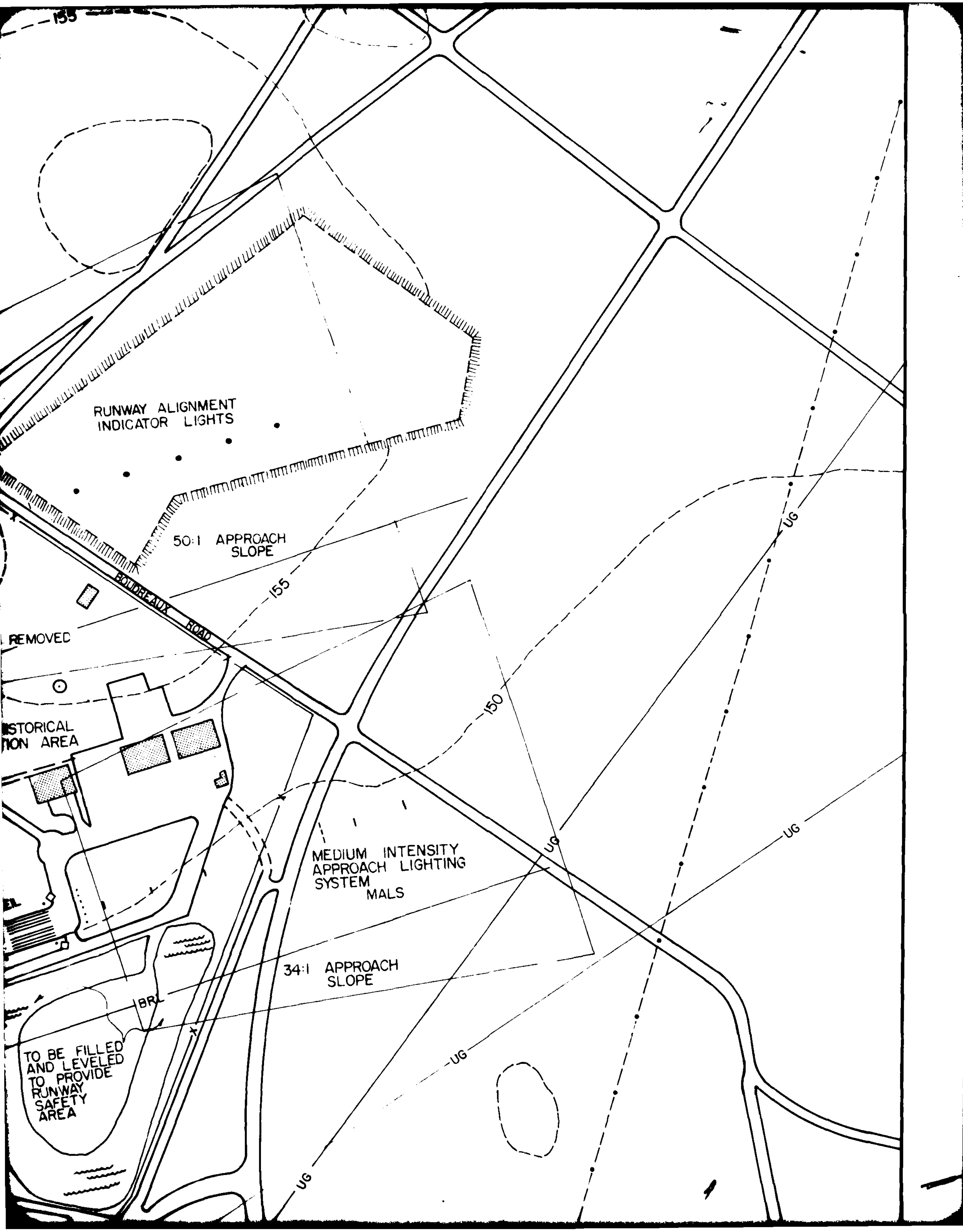
2
155
150
UG
UG
UG
UG
UG
BRL
145
BRL
UG
UG
UG
BRL
VASI-4
35
REIL
150
UG



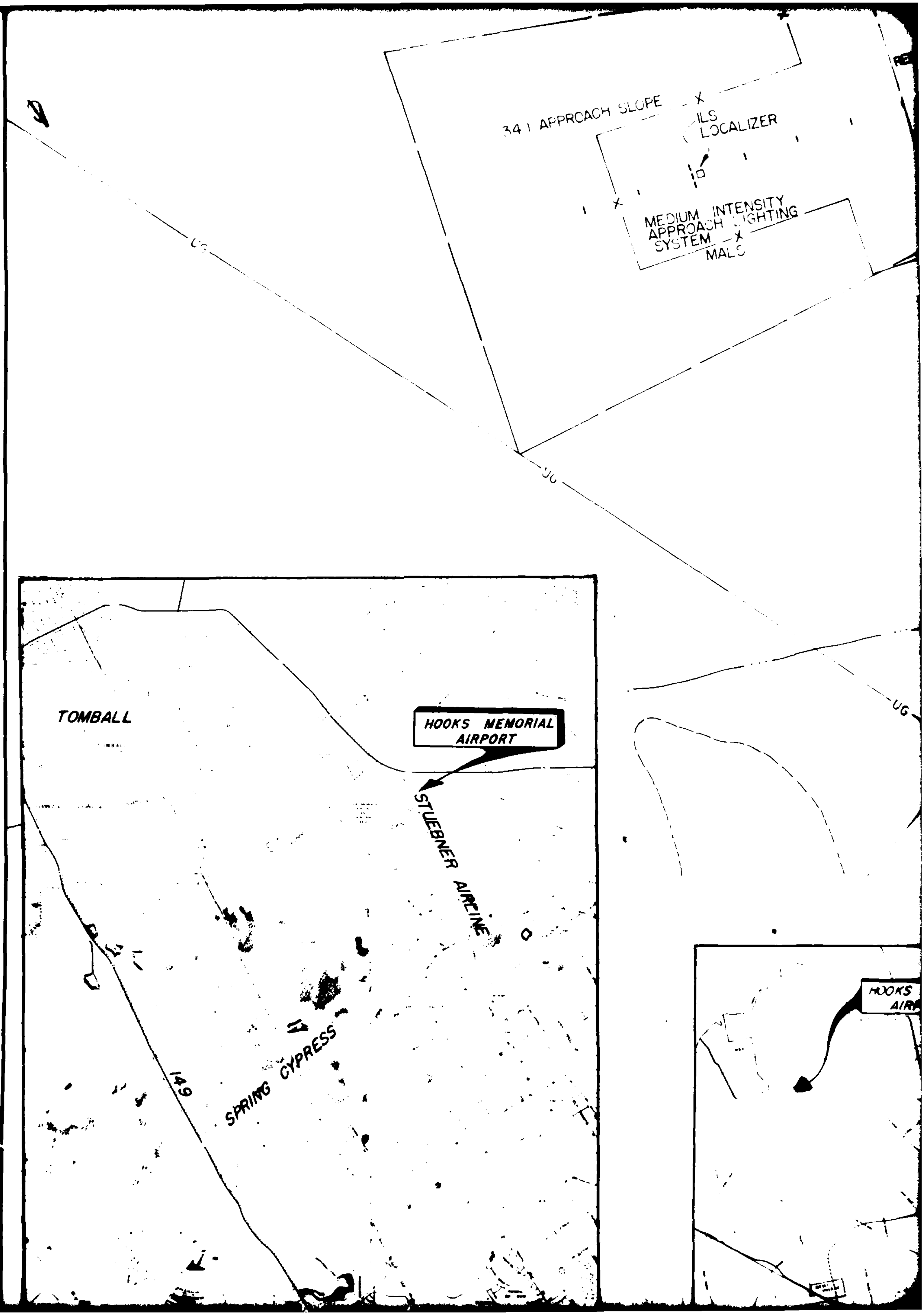
155
UG
UG
UG
UG
UG
UG
UG
BRL
BRL
BRL
BRL
BRL
BRL
MEDIUM INTENSITY APPROACH LIGHTING SYSTEM
MALSR
REIL
ILS GLIDE SLOPE INDICATOR
155
17R
VASI-4
FIRE, CRASH & RESCUE
FAA CONTROL TOWER
SEGMENTED WIND CIRCLE

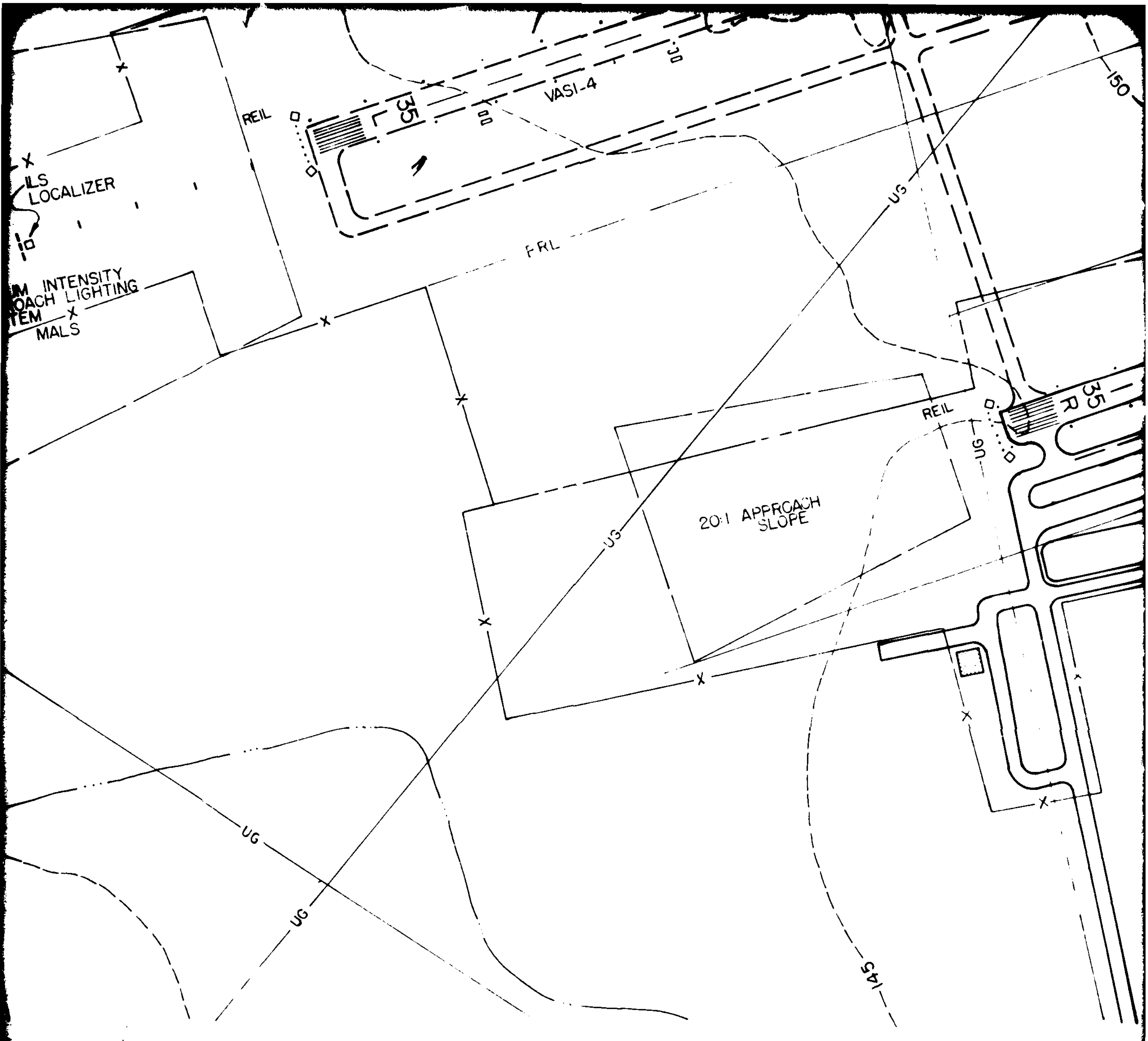


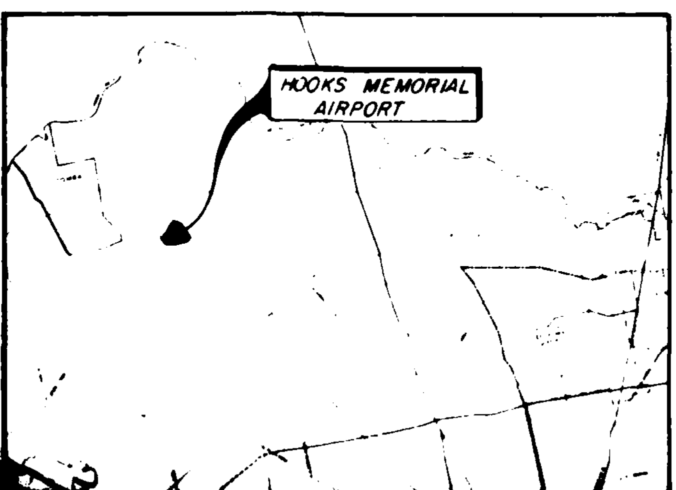
4
155
UG
RUNWAY ALIGNMENT
INDICATOR LIGHTS
UM INTENSITY
ROACH LIGHTING
TEM
MALSR
50:1 APPROACH
SLOPE
BOUDREAUX ROAD
155
TO BE REMOVED
APPROXIMATE
LIMITS OF HISTORICAL
PRESERVATION AREA
150
SH
CUE
BRL
REIL
MEDIUM INTENSITY
APPROACH LIGHTING
SYSTEM
MALS
UG
34:1 APPROACH
SLOPE
BRL
VASI-4
TO BE FILLED
AND LEVELED
TO PROVIDE
RUNWAY
SAFETY
AREA
UG
FUELING
AREA



155
RUNWAY ALIGNMENT INDICATOR LIGHTS
50:1 APPROACH SLOPE
BOUDREAUX ROAD
155
REMOVED
150
ISTORICAL
TION AREA
UG
MEDIUM INTENSITY APPROACH LIGHTING SYSTEM MALS
34:1 APPROACH SLOPE
BRL
TO BE FILLED AND LEVELED TO PROVIDE RUNWAY SAFETY AREA
UG
UG
UG

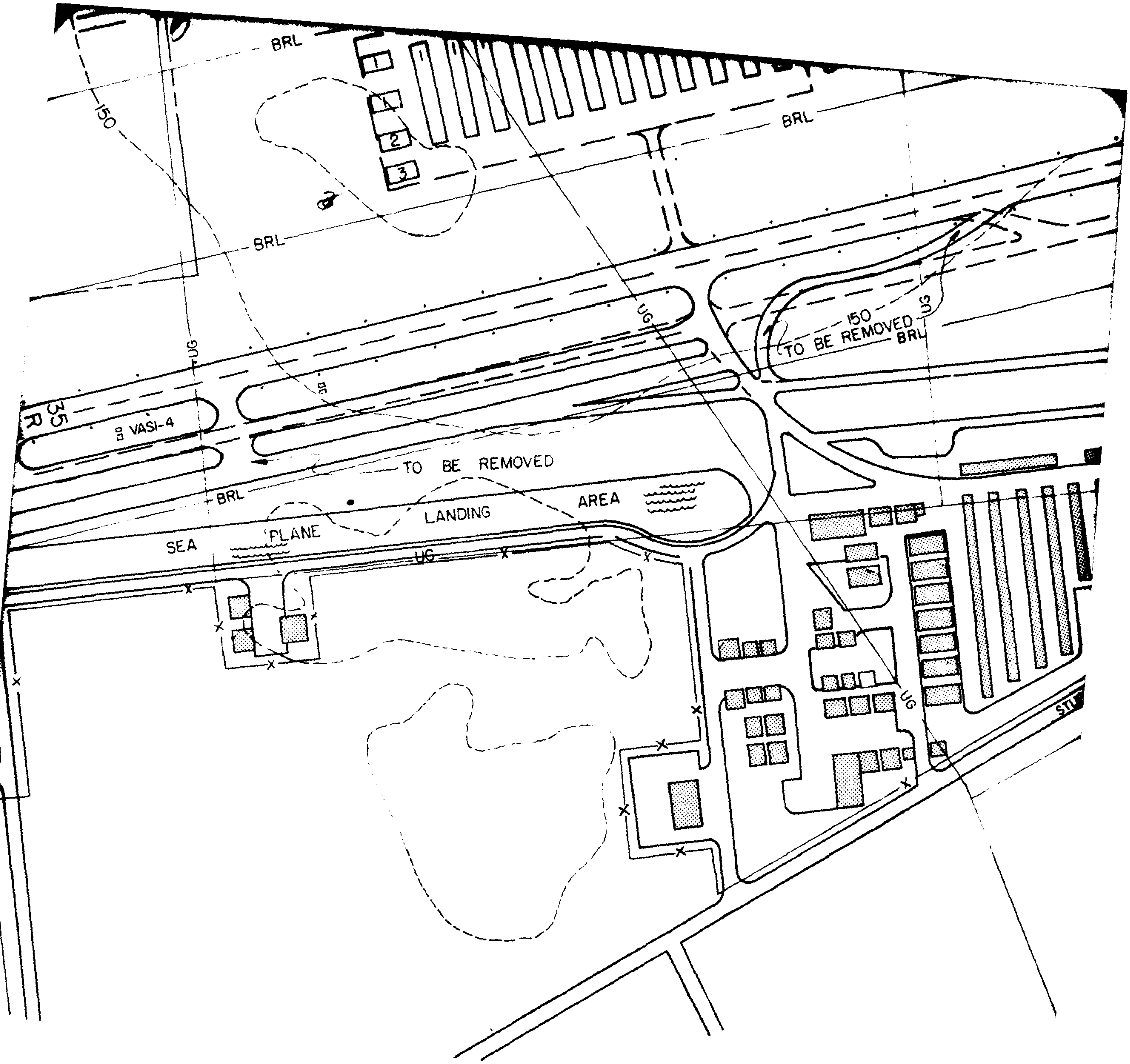

34 L APPROACH SLOPE
ILS LOCALIZER
MEDIUM INTENSITY APPROACH LIGHTING SYSTEM
MALS
UG
UG
UG
TOMBALL
HOOKS MEMORIAL AIRPORT
STUEBNER AIRLINE
SPRING CYPRESS
149
HOOKS





BASIC DATA TABLE

MEAN MAX. OF HOTTEST MONTH 94°	R/W 17L-35R	
	EXISTING	ULTIMA
R/W LENGTH & WIDTH	5340'X110'	5340'X
EFF. RUNWAY GRADIENT	0.1%	0.1
PERCENT WIND COVERAGE	94.5	94.5
PAVEMENT STRENGTH (1)	30	30
LIGHTING	LOW	MIR
MARKING	BASIC	NP
NAVIGATIONAL AIDS	NDB	NP



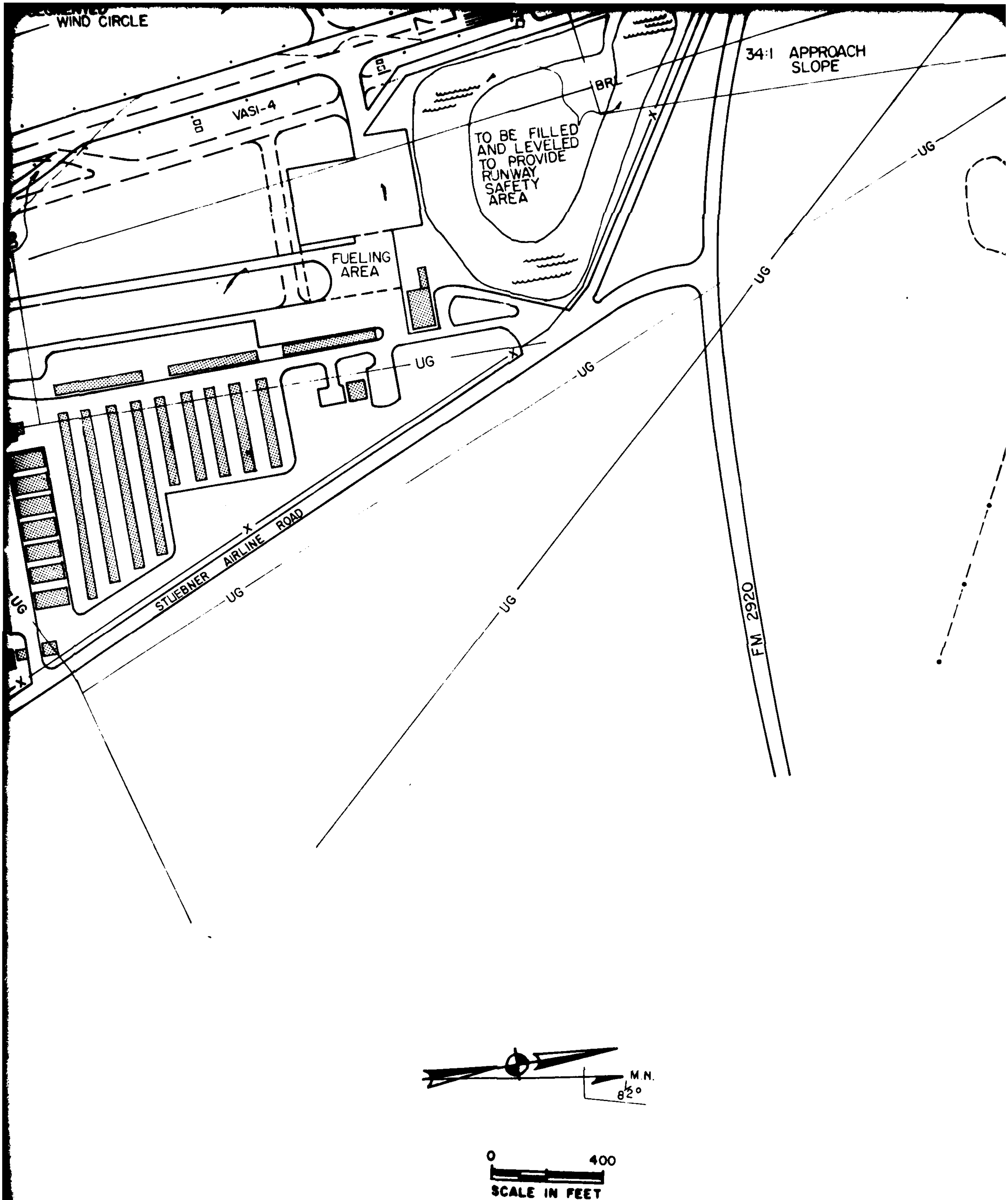
LE

-35R	R/W 17R-35L
ULTIMATE	ULTIMATE
340'X110'	6000'X100'
0.1%	0.1%
94.5	94.5
30	30, 45, 73(2)
MIRL	MIRL

LEGEND

APPROXIMATE EXIST. AIRPORT PROPERTY LINE

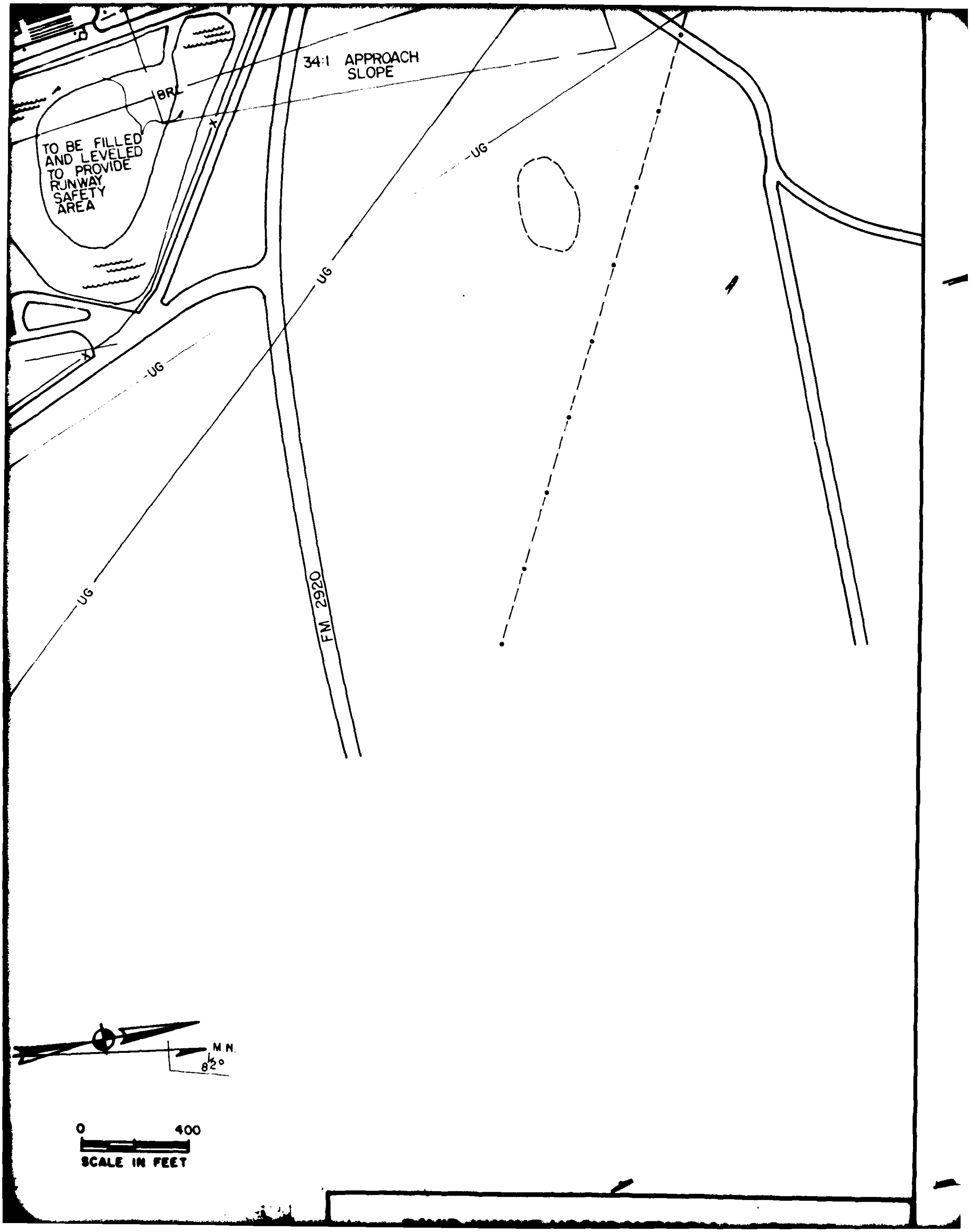
1 2 3

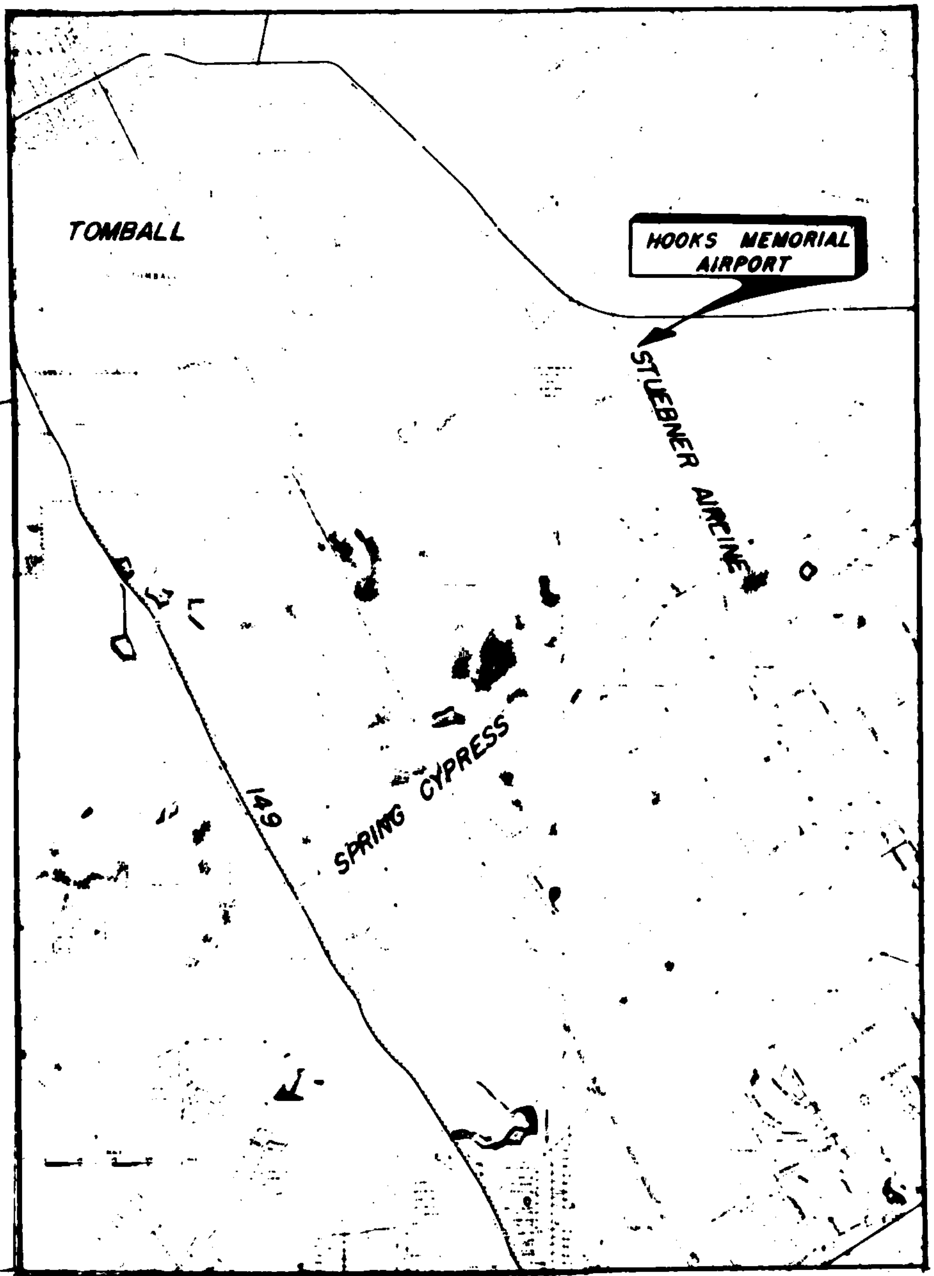


GEND

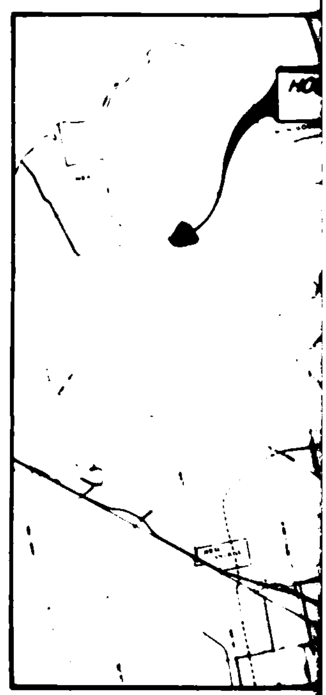
PERTY LINE

DAVID WAYNE

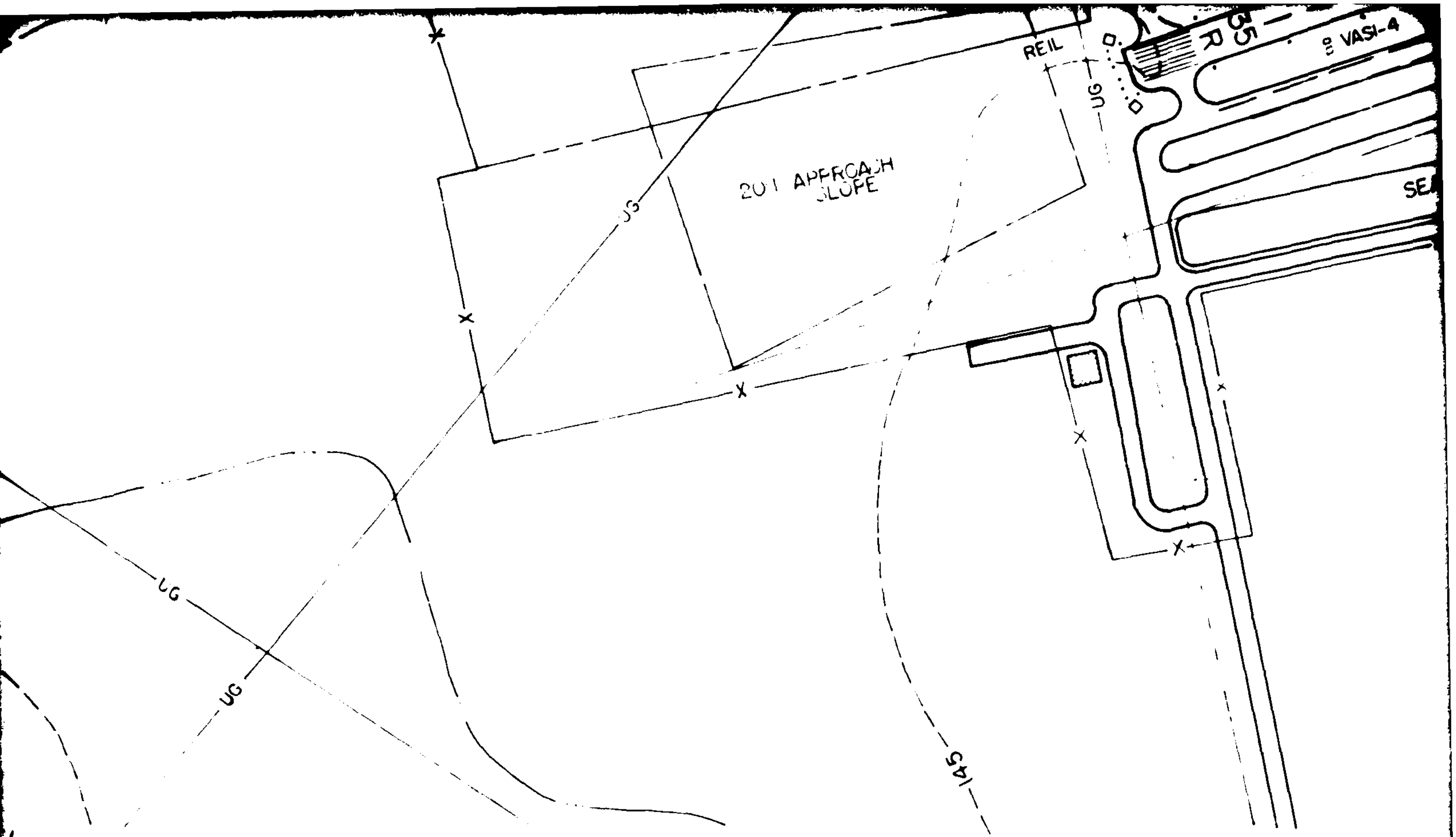

34:1 APPROACH
SLOPE
BRL
TO BE FILLED
AND LEVELED
TO PROVIDE
RUNWAY
SAFETY
AREA
UG
UG
UG
UG
FM 2920
M.N.
8½°
0
400
SCALE IN FEET

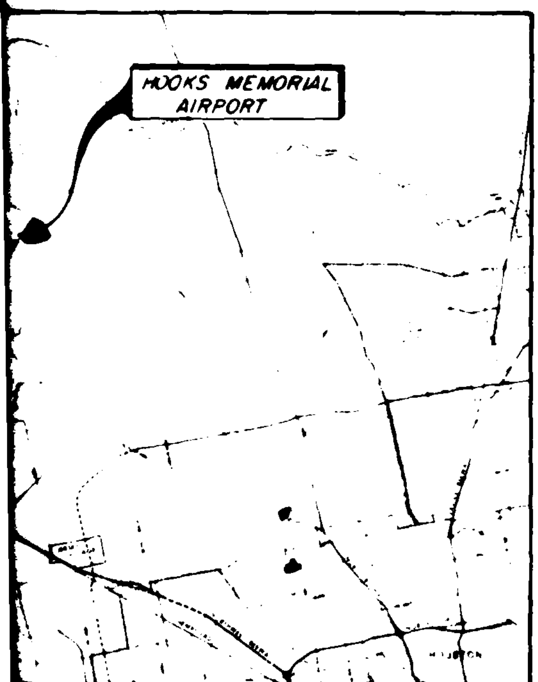


VICINITY MAP



LOCAT





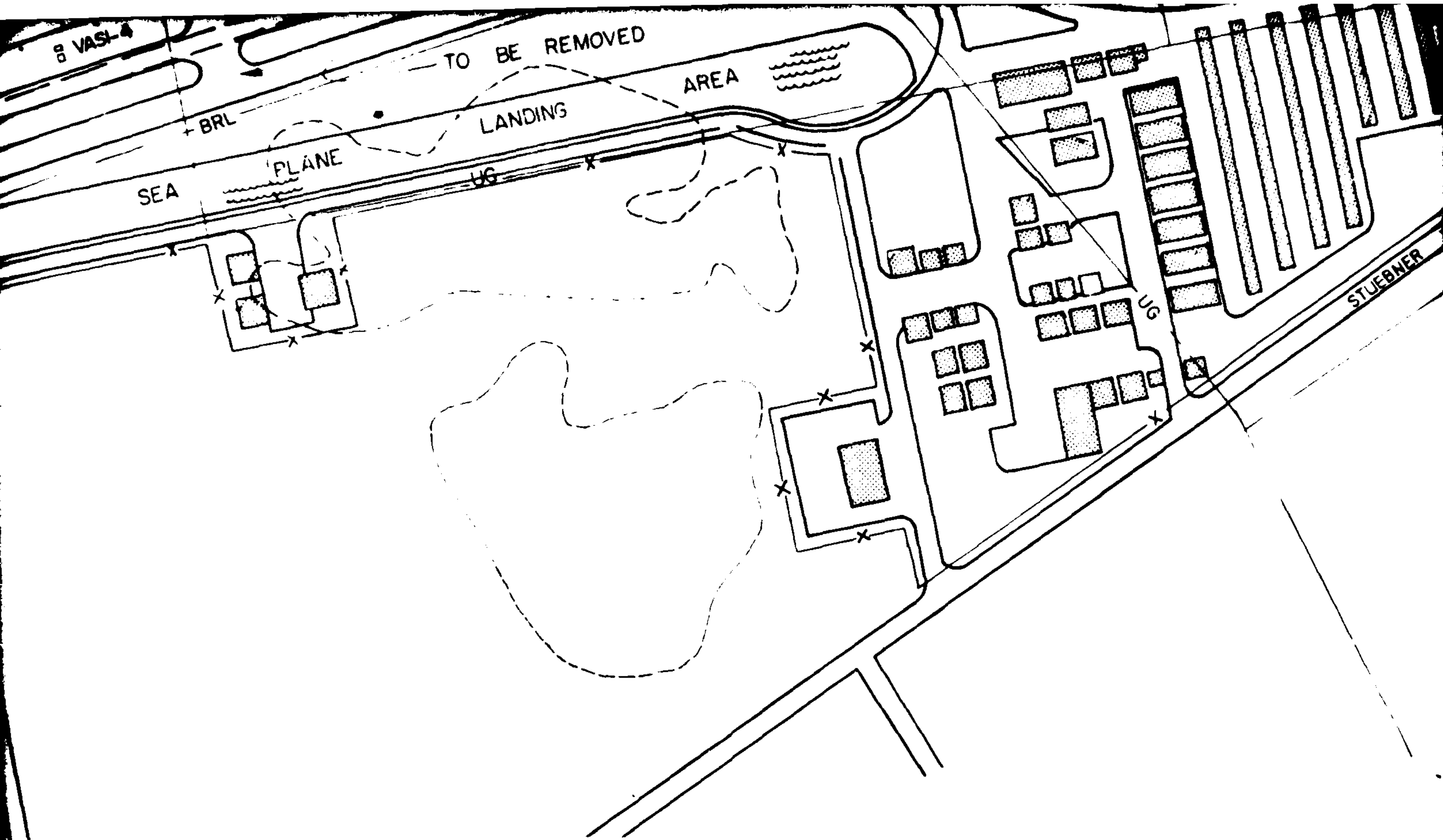
LOCATION MAP

BASIC DATA TABLE

MEAN MAX OF HOTTEST MONTH 94°	R/W 17L-35R		R/W 1
	EXISTING	ULTIMATE	ULT
R/W LENGTH & WIDTH	5340'X110'	5340'X110'	600
EFF. RUNWAY GRADIENT	0.1%	0.1%	0
PERCENT WIND COVERAGE	94.5	94.5	94
PAVEMENT STRENGTH (1)	30	30	30, 4
LIGHTING	LOW	MIRL	M
MARKING	BASIC	NP	INSTR
NAVIGATIONAL AIDS	NDB	NDB	I
VISUAL AIDS	REIL	REIL-VASI-MALS	VASI-R
APPROACH SLOPE	20:1	17L-34:1 35R-20:1	17R 35L
CRITICAL AIRCRAFT	GEN. UTIL	GEN. UTIL.	BAS.
ELEVATION (MSL)	149'	149'	1

(1) ESTIMATED PAVEMENT GROSS LOADING (1,000 LB)
(2.) SINGLE GEAR, DUAL GEAR, DUAL TANDEM GEAR.

12



R	R/W 17R-35L
TE	ULTIMATE
X110'	6000' X 100'
%	0.1%
	94.5
	30, 45, 73 (2)
L	MIRL
	INSTRUMENT
	ILS
-MALS	VASI-REIL-MALS
:1 0:1	17R-50:1 35L-34:1
TIL.	BAS. TRANS.
	149'

LEGEND

APPROXIMATE EXIST. AIRPORT PROPERTY LINE

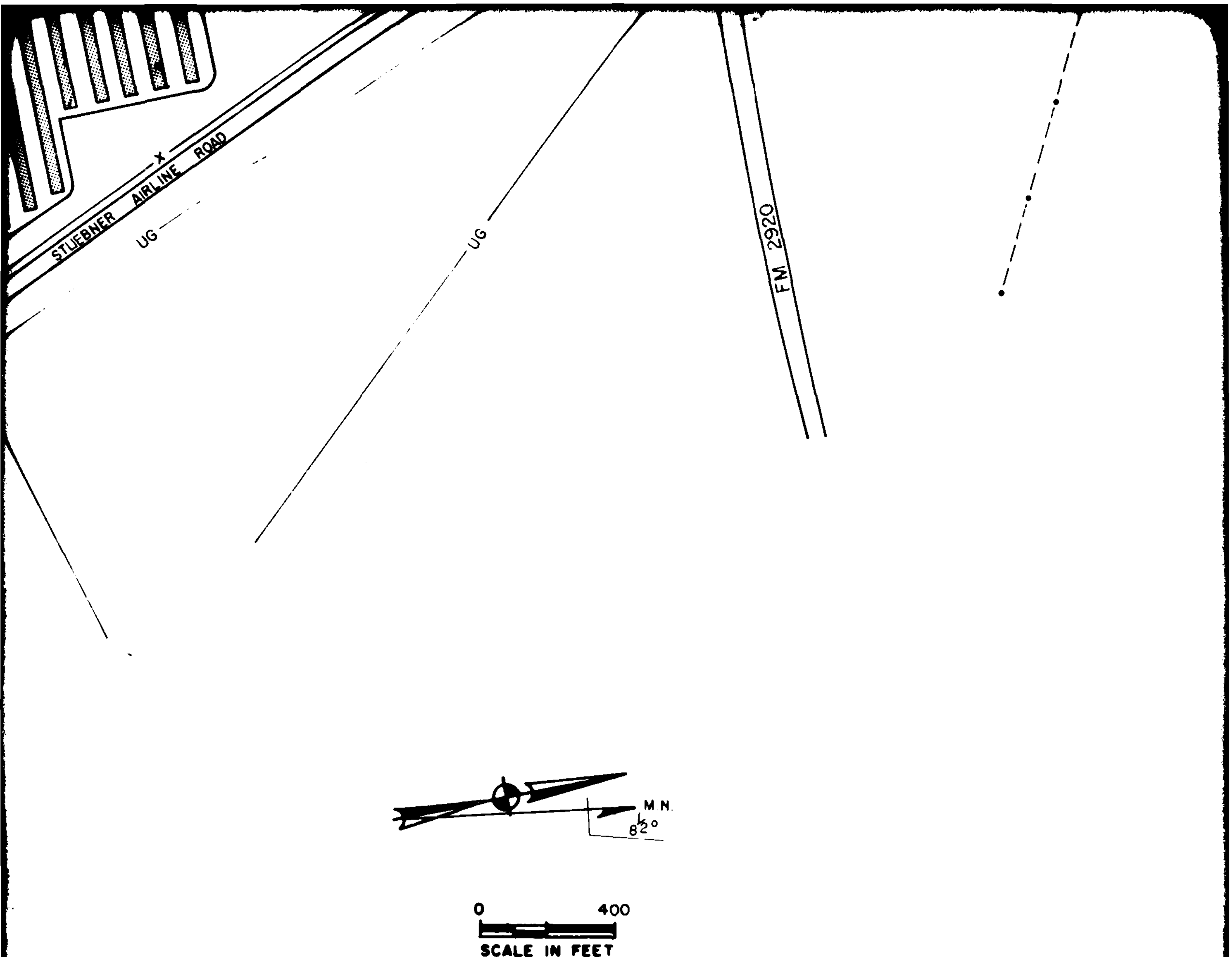
1 2 3 DEVELOPMENT PHASES 1=1982, 2=1987, 3=1997

—UG— EXISTING UNDERGROUND PIPELINE

—145— EXISTING GROUND CONTOUR LINE

EXISTING FACILITIES

POWER LINE



LINE — FUTURE FACILITIES

997 — EXISTING BUILDINGS

APPROACH AND CLEAR ZONE AREA
TO BE REQUIRED

EDGE LIGHTING SYSTEM

PROPOSED PROPERTY LINE

BRL — BUILDING RESTRICTION LINE

DAVID WAYNE HOOKS MEM

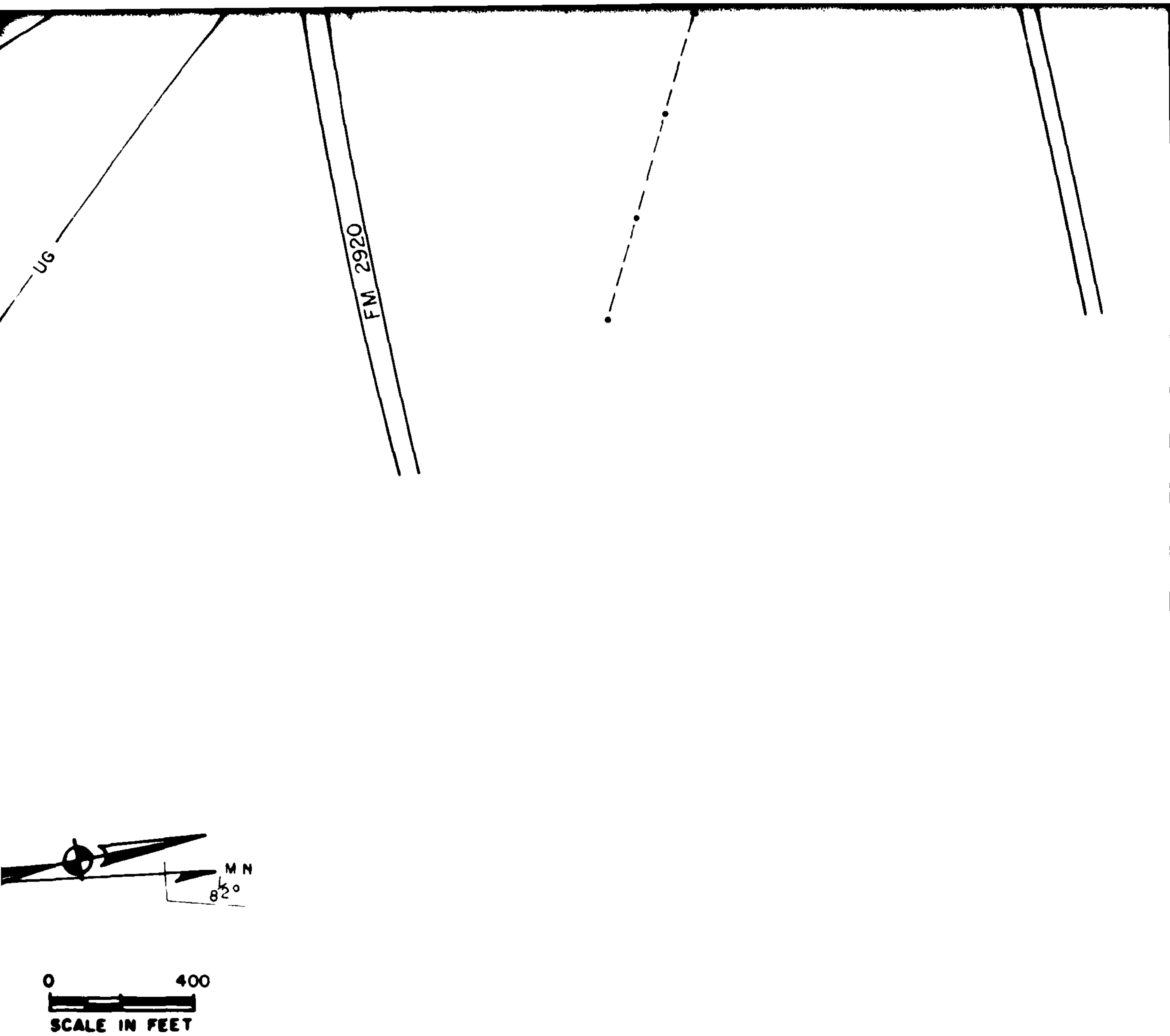
HARRIS COUNTY

AIRPORT LAYO

Turner Collie & Brad

Consulting Engineers

Exhibit 2 Job No. 2280-010



CILITIES

LDINGS

D CLEAR ZONE AREA
ED

HTING SYSTEM

OPERTY LINE

STRICTION LINE

DAVID WAYNE HOOKS MEMORIAL AIRPORT

HARRIS COUNTY, TEXAS

AIRPORT LAYOUT PLAN

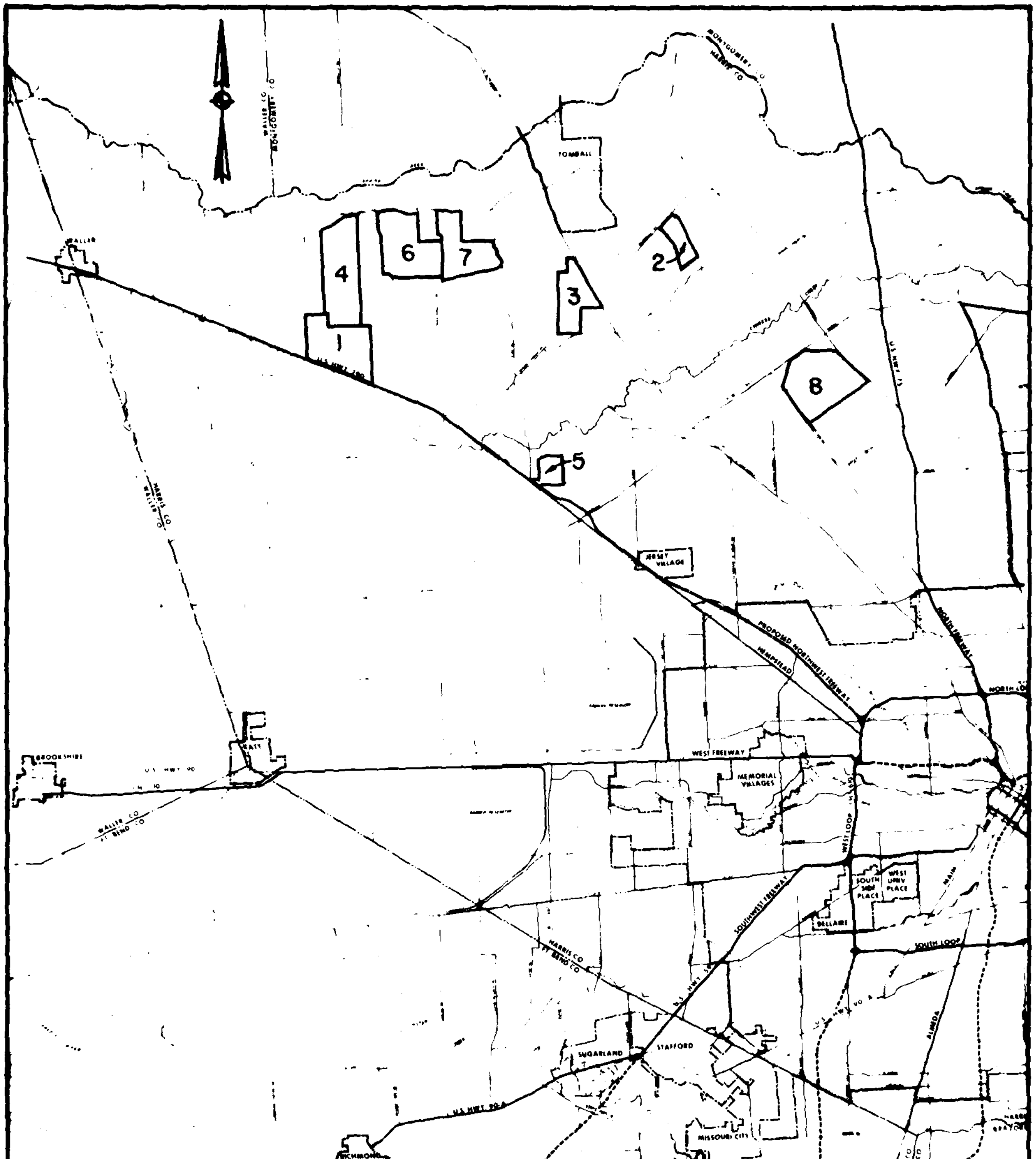
Turner Collie & Braden Inc.
Consulting Engineers

AUSTIN
DALLAS
HOUSTON
PORT ARTHUR

Exhibit 2	Job No. 2280-010	Date NOVEMBER 1978

14

15



NORTHWESTERN HARRIS COUNTY AIRPORT
MASTER PLAN STUDY
HARRIS COUNTY, TEXAS

SITE SELECTION

Turner Collie & Braden Inc.
Consulting Engineers
AUSTIN
DALLAS
HOUSTON
PORT ARTHUR

Exhibit 3	Job No. 2280-010	Date Dec. 1978

[illegible] AIRPORT

HARRIS COUNTY, TEXAS

65 LDN
NOISE CONTOUR-1978
EXISTING CONDITIONS

Turner Collie & Braden Inc.

Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit [illegible]	Job No 2280-010	Date [illegible]

DAVID WAYNE HOOKS MEMORIAL AIRPORT
HARRIS COUNTY, TEXAS

65 LDN
NOISE CONTOUR
1982

Turner Collie & Braden Inc.
Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 5	Job No. 2280-010	Date DECEMBER 1978

DAVID WAYNE HOOKS MEMORIAL AIRPORT

HARRIS COUNTY, TEXAS

65-75 LDN
NOISE CONTOUR
1986

Turner Collie & Braden Inc.

Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 6	Job No. 2280-010	Date DECEMBER 1978

DAVID WAYNE HOOKS MEMORIAL AIRPORT
HARRIS COUNTY, TEXAS

65 - 75 LDN
NOISE CONTOUR
1987

Turner Collie & Braden Inc.
Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 7	Job No. 2280-010	Date DECEMBER 978

0
1000
SCALE IN FEET

DAVID WAYNE HOOKS MEMORIAL AIRPORT

HARRIS COUNTY, TEXAS

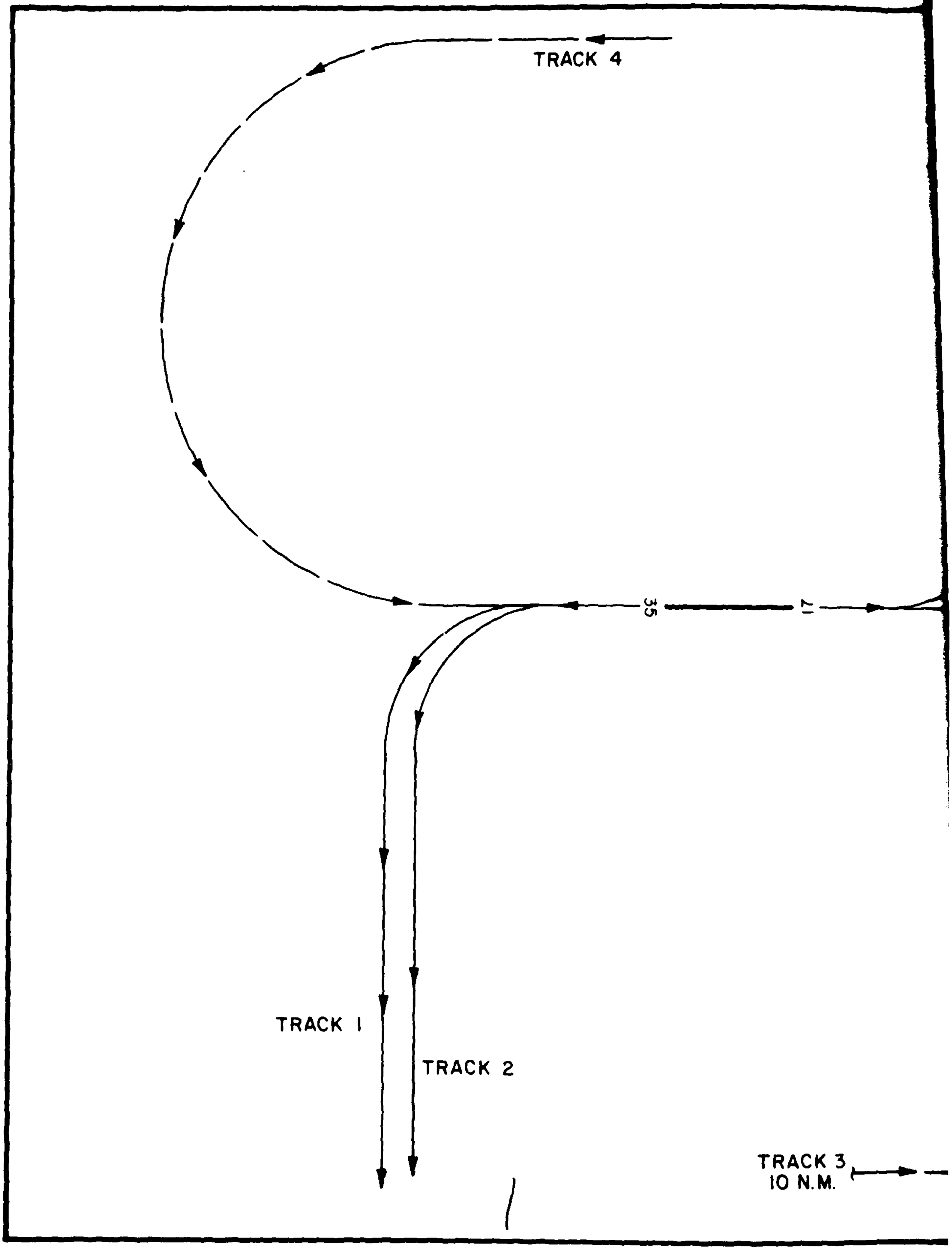
65-75 LDN
NOISE CONTOUR
1997

Turner Collie & Braden Inc.

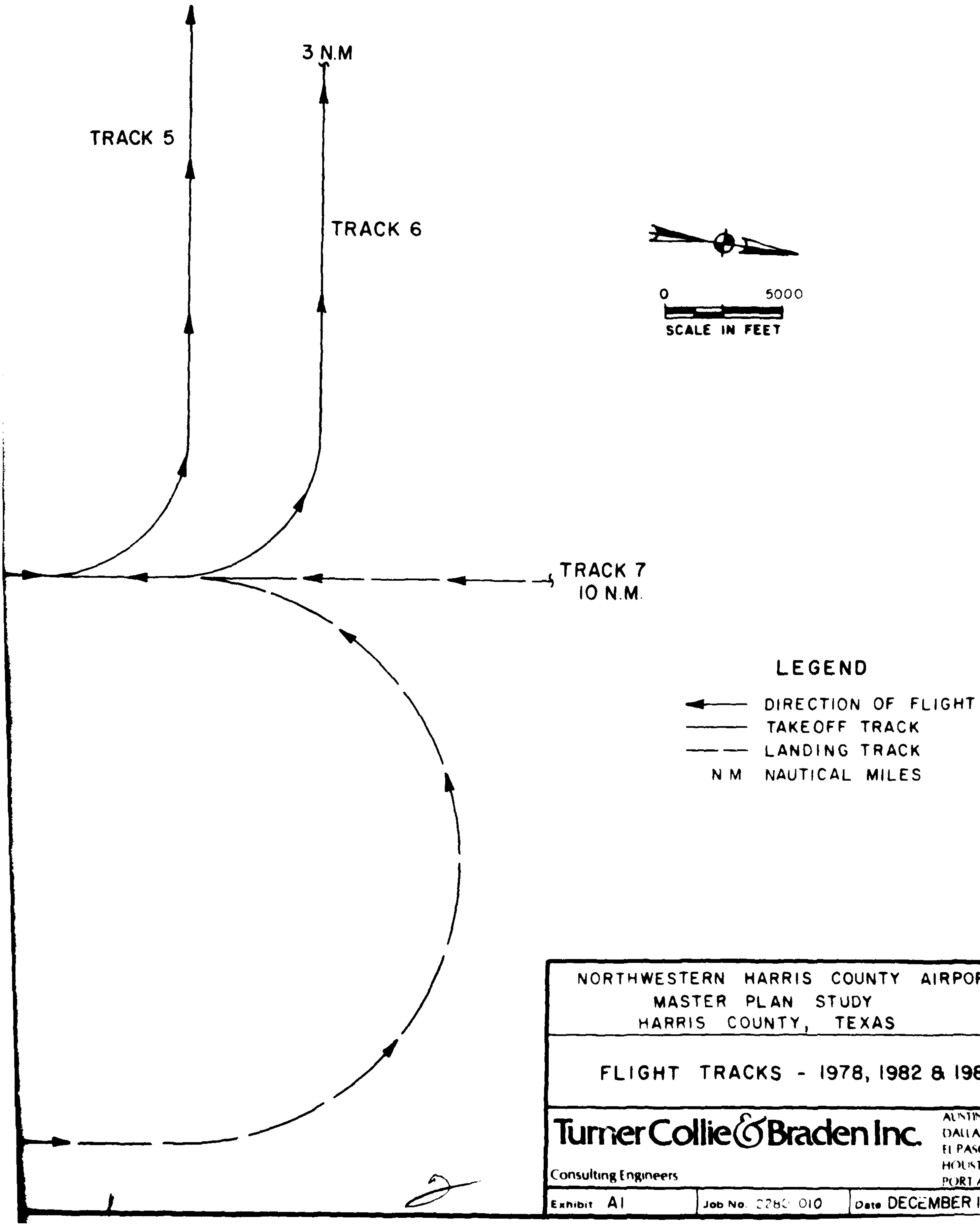
Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 8	Job No 2280-010	Date DECEMBER 978



TRACK 4
35
17
TRACK 1
TRACK 2
TRACK 3
10 N.M.



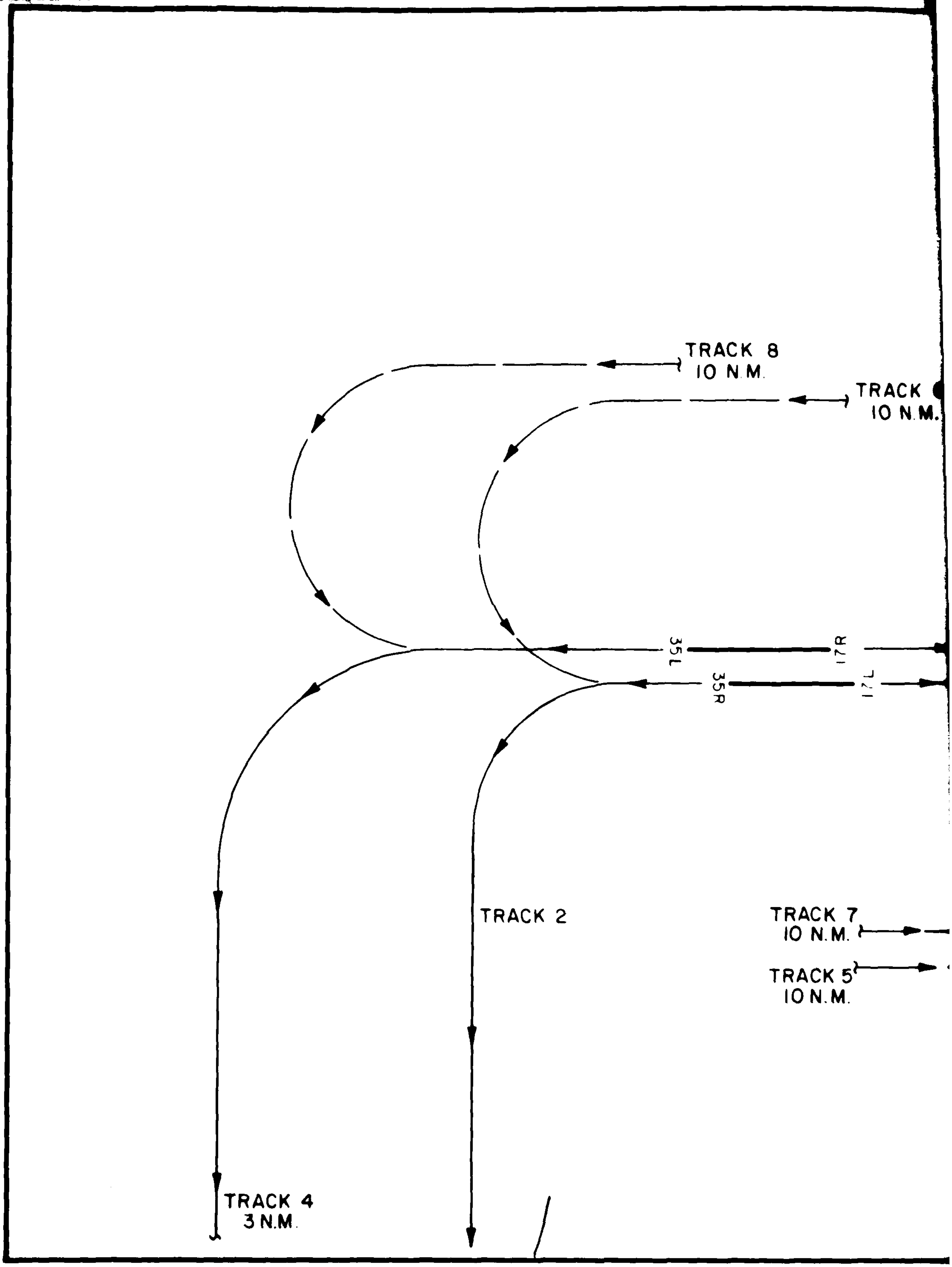
NORTHWESTERN HARRIS COUNTY AIRPORT
MASTER PLAN STUDY
HARRIS COUNTY, TEXAS

FLIGHT TRACKS - 1978, 1982 & 1986

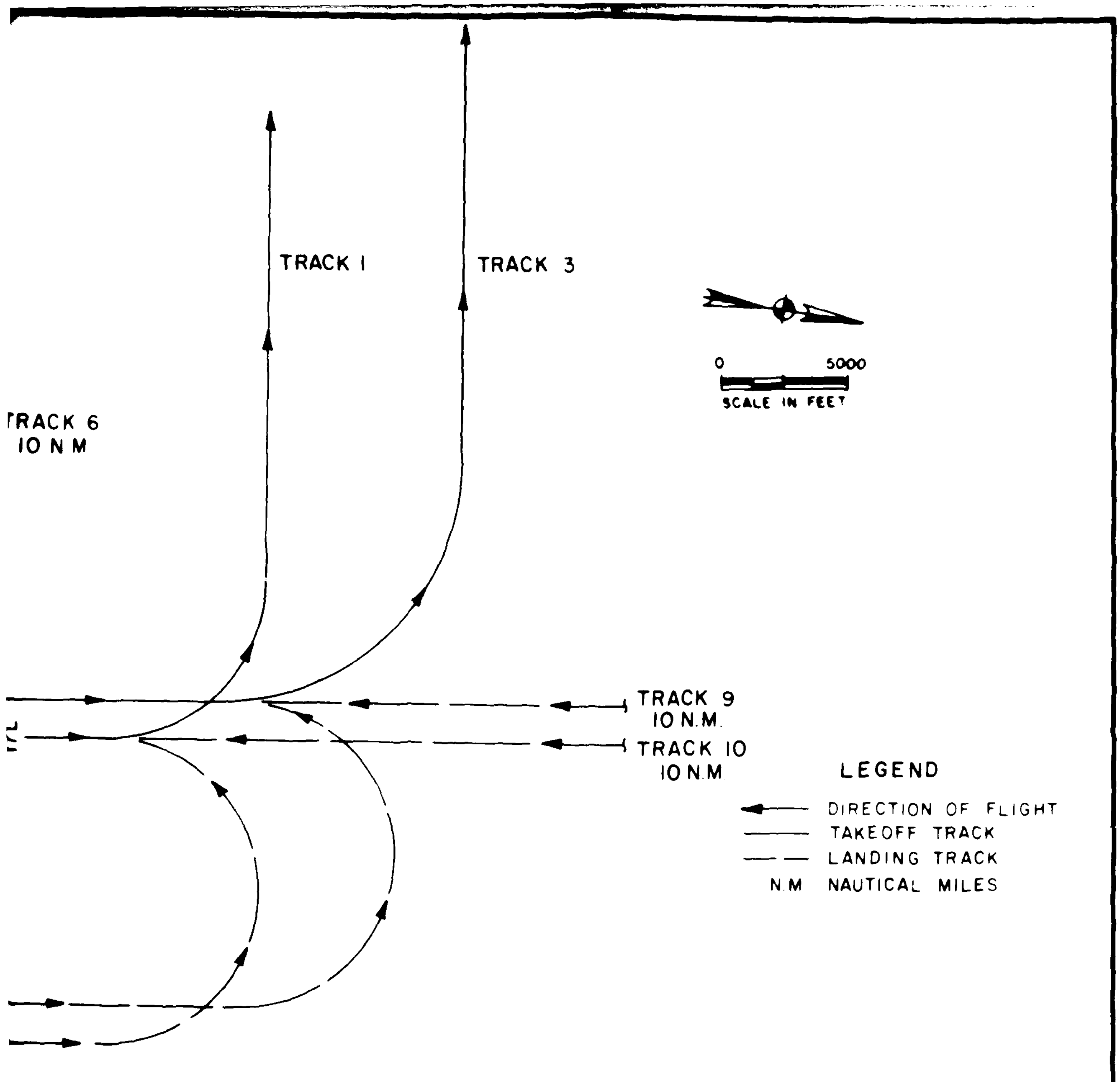
Turner Collie & Braden Inc.
Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit A1	Job No. 2280 010	Date DECEMBER 1978



TRACK 8
10 N.M.
TRACK
10 N.M.
35L
17R
35R
17L
TRACK 2
TRACK 7
10 N.M.
TRACK 5
10 N.M.
TRACK 4
3 N.M.



NORTHWESTERN HARRIS COUNTY AIRPORT
MASTER PLAN STUDY
HARRIS COUNTY, TEXAS

FLIGHT TRACKS - 1987 & 1997

Turner Collie & Braden Inc.
Consulting Engineers
AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

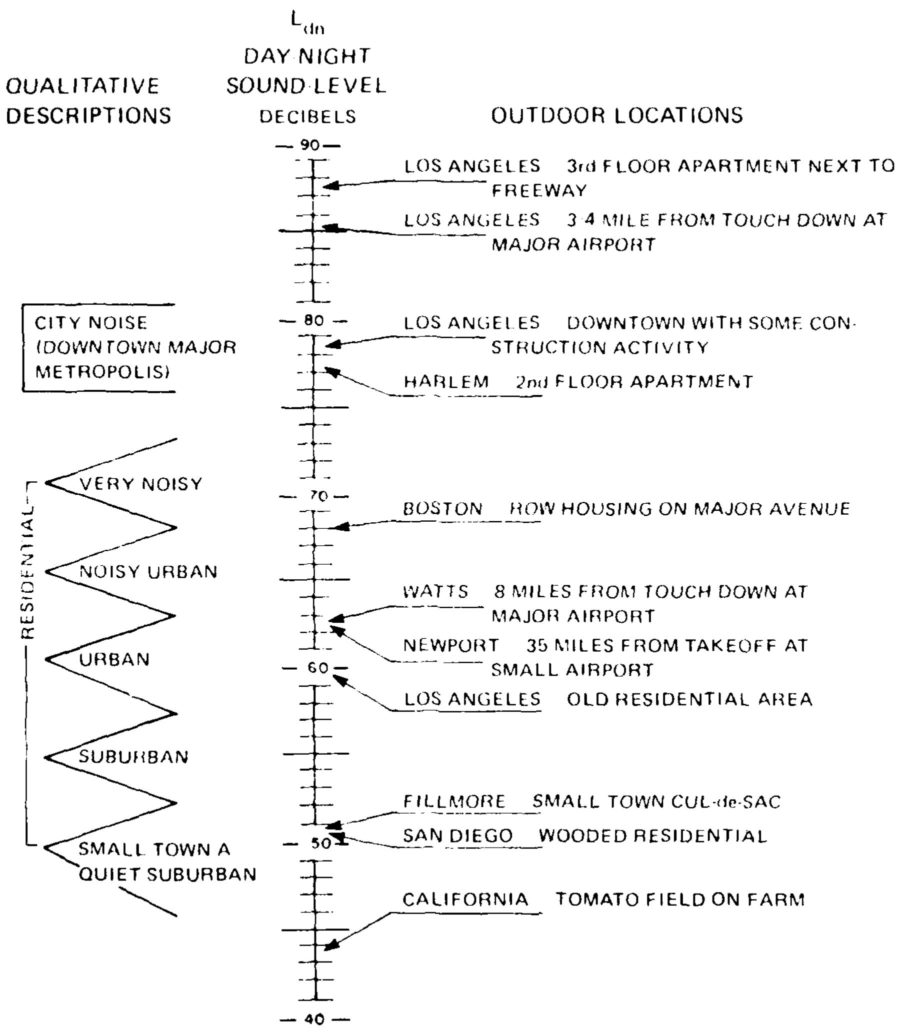
Exhibit A2	Job No 2280-010	Date DECEMBER 1978

APPENDIX A - FEDERAL AVIATION ADMINISTRATION INTEGRATED NOISE MODEL

The FAA has developed the INM, a computer program package, which can be used to predict the noise impacts of aircraft in the neighborhood of an airport. By using the INM, the airport planner can model mathematically a wide variety of potential scenarios for an airport. Although several different metrics are available for the INM, this study used the Ldn noise descriptor. Developed by the Environmental Protection Agency in 1974, the Ldn (also called "Day-Night level") is the average (nonenergy basis) A-weighted noise level over a 24-hour period. Appropriate weightings are applied for the noise levels occurring in the daytime and nightime periods. For example, the Ldn is weighted to account for the quieter background noise levels from 10:00 p.m. to 7:00 a.m., with a 10 dB penalty applied for aircraft operating during these hours. Thus, the Ldn provides a single number measure of time-varying noise for a specified time period. Table Al shows a comparison of Ldn noise levels to several qualitative outdoor descriptions. The Ldn can be measured directly at existing airports using portable monitoring equipment. Typical contour values usually range from less than 55 Ldn for lightly impacted areas to more than 75 Ldn for heavily impacted areas. Table Al shows a comparison of Ldn noise levels to several qualitative outdoor descriptions.

The resultant noise contours from the INM and presented in Exhibits 4 thru 8 conform to the guidelines of FAA Order 1050lB,

TABLE A-1
OUTDOOR DAY-NIGHT SOUND LEVEL
in dB AT VARIOUS LOCATIONS



"Policies and Procedures for considering Environmental Impacts," June 16, 1977. The 65 and 75 Ldn (Exhibit 6, 7, and 8 only) in the Exhibits represent the boundary of all areas exposed to noise levels equal to or greater than Ldn 65 or 75.

In order to use the INM to project the future noise levels presented in this report, the analyst must prepare the following data for input into the computer:

I. Runway Configuration including Length and Orientation

II. Flight Characteristics

  A. Landing Profile

  B. Approach and Departure Tracks

  C. Runway Usage Based on Prevailing Wind Direction

III. Existing and Forecast Aviation Activity by Aircraft Type

  A. Aircraft

  B. Stage Lengths

  C. Operational Characteristics

  D. Day, Evening, and Night Operations

Exhibits A1 and A2 are the flight tracks for the existing and proposed airport.

APPENDIX B - "BOX MODEL" METHOD OF AIR QUALITY COMPUTATION

The "Box Model"

Air quality estimates for noncontroversial, noncritical situations may be made through use a Box Model technique. The Box Model method of air quality computation uses the emissions generated in a unit landing and take-off operation (LTO cycle) as the basic parameter for estimates. In order to be consistent with the formation of the model, metric units are used in all associated calculations. The number of LTO cycles is based on peak-hour operations. The dimensions of the box are associated with aircraft type. Its length is a typical distance between the points where the aircraft descends to 1,100 meters above the runway on approach and where it reaches 1,100 meters again on departure. The 1,600 meter width of the box is arbitrary. Box dimensions for various type aircraft are shown on Table B1.

Table B2 shows emissions in terms of pounds per engine for a variety of aircraft for general background information. Total emissions resulting in a peak hour on an average day or from annual operations may be estimated in terms of the forecast number of LTO cycles for each condition. Actual times and emissions may be more or less, depending upon airport configuration and operating condition.

TABLE B1 – MIXING VOLUMES AND AMOUNTS OF EMISSIONS

Type Aircraft	LTO Cycle Minutes	Closed Box Model Dimensions Meters Length	Meters Width	Meters Depth	Volume Meters^3
Long-range jet	13.9	23,100	1,600	1,100	$40,656 \times 10^6$
Medium-range jet	13.9	23,200	1,600	1,100	$40,656 \times 10^6$
Business jet	9.0	7,800	1,600	1,100	$13,790 \times 10^6$
Air carrier turboprop	14.5	22,500	1,600	1,100	$39,400 \times 10^6$
General aviation	14.5	22,500	1,600	1,100	$39,400 \times 10^6$
Air carrier piston	16.7	30,700	1,600	1,100	$54,000 \times 10^6$
General aviation piston	17.9	27,600	1,600	1,100	$48,600 \times 10^6$

Source: Compilation of Air Pollutant Factors, Second Edition, U.S. Environmental Protection Agency, April, 1973.

TABLE B2 – EMISSION FACTOR RATINGS PER AIRCRAFT ENGINE LTO CYCLE (lbs per engine)

Type Aircraft	Particulates	Sulfur Oxides	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Long-range jet	1.210	1.560	47.400	41.200	7.900
Medium-range jet	0.410	1.010	17.000	4.900	10.200
Business jet	0.110	0.370	15.800	3.600	1.600
Air carrier turboprop	1.100	0.400	6.600	2.900	2.500
General aviation turboprop	0.20	0.180	3,100	1.100	1.200
Air carrier piston	0.560	0.280	304.000	40.700	0.400
General aviation piston	0.020	0.014	12.200	0.400	0.047
Helicopter	0.250	0.180	5.700	0.520	0.570

Source: Compilation of Air Pollutant Emission Factors, Second Edition, U.S. Environmental Protection Agency, Table 3.2 – 1.3, April, 1973.

Table B3 shows concentration of emissions determined for various aircraft types and for each LTO cycle. The Box Model is a "worst case" model. Meteorological data such as accurate wind speeds, wind directions, and vertical air movement which would dilute and disperse pollutants have not been considered in the evaluation process. The extreme condition of pollution occurs during peak-hour operations when wind speed is low. The values shown in the table assume a wind speed of one meter per second. This speed in representative of the more extreme conditions of concern regarding pollution; i.e., a worst case situation. During a typical hour when wind speed is, for example, ten meters per second, concentrations would be ten percent of the indicated values because air in the box is being replaced by new air at ten meters per second instead of one meter per second.

Table B4 is prepared after determining the forecast number of LTO cycles of each air type during a peak hour operation. Predicted concentrations are the sum of concentrations determined for each aircraft type using the airport. Projected peak hour LTO cycles for Hooks Airport are as follows:

Time Phase	Peak LTO Cycles/hour
1982	34
1986	37
1987	38
1997	43

TABLE B3 - EMISSION CONCENTRATIONS PER AIRCRAFT[1] LTO CYCLE

Type Aircraft	No. of Engines	Particulates $\mu g/m^3$	Sulfur Oxides $\mu g/m^3$	Carbon Monoxide mg/m^3	Hydro carbons $\mu g/m^3$	Nitrogen oxides $\mu g/m^3$
Long-range jet	4	0.054	0.069	0.0021	1.839	0.354
	3	0.041	0.052	0.0015	1.379	0.266
Medium-range jet	4	0.019	0.045	0.0007	0.216	0.453
	3	0.014	0.034	0.0006	0.162	0.339
	2	0.009	0.023	0.0004	0.108	0.226
Business jet	4	0.015	0.049	0.002	0.463	0.212
	2	0.008	0.025	0.001	0.231	0.106
Air carrier turboprop	4	0.049	0.018	0.0003	0.132	0.112
	2	0.024	0.0009	0.0002	0.066	0.056
General aviation turboprop	2	0.005	0.004	0.0001	0.025	0.027
Air carrier piston	4	0.019	0.010	0.010	1.369	0.013
	2	0.009	0.005	0.005	0.685	0.007
General aviation piston	2	0.0004	0.0002	0.0002	0.007	0.0009
	1	0.0002	0.0001	0.0001	0.004	0.0005

[1] The emissions data shown are the *totals for the type aircraft*. *Do not* multiply the emission data by the number of engines.

Source: Compilation of Air Pollutant Emission Factors, Second Edition, U.S. Environmental Protection Agency, April, 1973.

TABLE 24
AIR QUALITY ANALYSIS
D. W. HOOKS MEMORIAL AIRPORT
NORTHWESTERN HARRIS COUNTY AIRPORT MASTER PLAN

Year	Aircraft Type	Estimated Peak LTO Cycles	Particulate Factor	μg/m³ Total	[illegible] Factor	μg/m³ Total	[illegible] Factor	μg/m³ Total	Hydrocarbon Factor	μg/m³ Total	[illegible] Factor	μg/m³ Total
1982	General Aviation Piston (1 engine)	26	.0002	.0052	.0001	.026	.0001	.0026	.004	.104	.0006	.13
	General Aviation Piston (2 engine)	5	.0004	.0029	.0002	.01	.0002	.001	.007	.035	.0004	.045
	General Aviation Turboprop	1	.005	.005	.04	.04	.0001	.001	.025	.025	.027	.027
	Business Jets (2 engine)	1	.008	.008	.25	.25	.001	.001	.231	.231	.106	.106
	Medium Range Jets (2 engine)	1	.009	.009	.23	.23	.0004	.004	.108	.108	.226	.226
	Total	34		.232		.56		.0051		.503		.5[illegible]5
1986	General Aviation Piston (1 engine)	26	.0002	.0052	.0001	.026	.0001	.0026	.004	.104	.0006	.13
	General Aviation Piston (2 engine)	6	.0004	.0024	.0002	.0012	.0002	.0012	.007	.042	.0009	.054
	General Aviation Turboprop	2	.005	.010	.004	.008	.0001	.0002	.025	.050	.027	.054
	Business Jets (2 engine)	2	.008	.016	.025	.050	.001	.002	.231	.462	.106	.212
	Medium Range Jets (2 engine)	1	.009	.009	.023	.023	.0004	.0004	.108	.108	.226	.226
	Total	37		.0426		.0148		.0064		.766		.5104
1987	General Aviation Piston (1 engine)	27	.0002	.0054	.0001	.0027	.0001	.0027	.004	.108	.0005	.0135
	General Aviation Piston (2 engine)	6	.0004	.0024	.0002	.0012	.0002	.0012	.007	.042	.0009	.0054
	General Aviation Turboprop	2	.005	.010	.004	.008	.0001	.0002	.025	.050	.027	.054
	Business Jets	2	.008	.016	.025	.050	.001	.002	.231	.462	.106	.212
	Medium Range Jets (2 engine)	1	.009	.009	.023	.023	.0004	.0004	.108	.108	.226	.226
	Total	38		.0428		.0849		.0065		.770		.5109
1997	General Aviation Piston (1 engine)	28	.0002	.0056	.0001	.0028	.0001	.0028	.004	.112	.005	.014
	General Aviation Piston (2 engine)	7	.0004	.0028	.0002	.0014	.0002	.0014	.007	.049	.0009	.0063
	General Aviation Turboprop	3	.005	.015	.004	.012	.0001	.0003	.025	.075	.027	.081
	Business Jets	4	.008	.032	.025	.100	.001	.004	.231	.924	.106	.424
	Medium Range Jets (2 engine)	1	.009	.009	.023	.023	.0004	.0004	.108	.108	.226	.226
	Total	43		.0641		.1392		.0089		1.268		.7513

Turner Collie & Braden Inc

A breakdown of LTO cycles by aircraft type is shown on Table B4. Table B4 also includes results from the Box Model analysis used to assess air quality impacts. Concentrations of pollutants that exceed standards can be determined from Table B5.

TABLE B5
AMBIENT AIR QUALITY STANDARDS

National Standards	Primary[1]	Secondary[2]
Carbon Monoxide (CO)	41 mg/m^3 hourly average, not to be exceeded more than once a year	same as primary
	10 mg/m^3 eight hour average, not to be exceeded more than once a year	
Nitrogen Dioxide (NO_2)	96 μg/m^3 annual average	same as primary
Non-methane Hydrocarbons[3]	160 μg/m^3 6-9 a.m. average, not to be exceeded more than once a year	same as primary
Photochemical Oxidants	0.08 ppm hourly average measured as ozone, not to be exceeded more than once a year	same as primary
Total Suspended Particulate Matter	260 μg/m^3 24 hour average, not to be exceeded more than once a year	150 μg/m^3 24 hour average not to be exceeded more than once a year
	75 μg/m^3 annual geometric mean	60 μg/m^3 annual geometric mean
Sulfur Dioxide (SO_2)	365 μg/m^3 (0.14 ppm) 24-hour average, not to be exceeded more than once a year	1,300 μg/m^3 (0.5 ppm) three hour average not to be exceeded more than once a year
	80 μg/m^3 (0.03 ppm) annual average	

[1] Primary standards define levels of air quality which the U.S. Environmental Protection Agency's (EPA) Administrator judges necessary to protect the public health with an adequate margin of safety.

[2] Secondary standards define levels of air quality which the EPA Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

[3] These are for use as guides in achieving other standards. The non methane hydrocarbon level relates to the oxidant standard; the 60 μg/m^3 geometric mean relates to the 24-hour standard for particulates.

APPENDIX C - CULTURAL RESOURCES ASSESSMENT DAVID WAYNE HOOKS MEMORIAL AIRPORT, HARRIS COUNTY

ARCON

CONSULTING SERVICES IN ARCHAEOLOGY

26 May 1978

Mr. Bill Griffin
Turner Collie & Braden, Inc.
5757 Woodway
Houston, TX 77057

Dear Mr. Griffin:

The enclosed report summarizes the results of my investigation of the Hooks Airport site. As expected, the sweetgum grove holds the only possible historical significance and I have made some suggestions for dealing with it in the future.

The work which I have done required three trips to the airport and surrounding area and considerable searching in the library at Rice and in Tomball. I quickly exceeded the time limits implied by the ceiling on my fee but I carried through until I felt that I understood the extent of the problem remaining.

I trust that the present report will serve your immediate purposes and I will, of course, be interested in following through in some fashion if that is deemed to be desirable by your company or others.

Sincerely yours,

Frank Hole

Frank Hole

FRANK HOLE • 5503 Sanford, Houston, Texas 77096 • (713) 721-2957

Cultural Resources Assessment
David Wayne Hooks Memorial Airport
Harris County, Texas

Abstract

At the request of Turner Collie & Braden, Inc., I have carried out a survey of the archeological and historical resources on the David Wayne Hooks Memorial Airport and the land to be affected by a proposed enlargement and improvement of existing facilities. The survey entailed both a physical examination of the premises and a review of historical information. Of the area to be affected, only that known as the "sweetgum grove" may have historical significance. I recommend that the grove be avoided during construction and that archeological and further historical investigation be undertaken to determine the precise nature of its role in history.

The Area

The David Wayne Hooks Memorial Airport is situated at the northern end of Harris County on the prairie between Cypress and Willow Creeks, land that was originally part of the Elizabeth Smith League of 1831 which straddled Willow Creek (Figure 1). The present environment looks remarkably different from that of the past. In the recording of the Elizabeth Smith grant, it was reported that 3/25 of the land was in forest and the remainder in pasture. This appears to be typical of the region; forests had advanced along the major streams but had not encroached out onto the prairie in the early 19th century. Today it is hard to visualize the prairie, for the forests have advanced rapidly; often there is dense forest today where in 1915 there was open grassland. As little as 15 years of disuse today results in an overgrowth of saplings and bushes which may stand 15 feet high. These marked changes in the distribution of local vegetation dictate that we pay less attention to what the land appears to be today and focus on what it was in the past if we are to understand aboriginal and early historic settlement.

In the past, the north part of Harris County lay near environmental and cultural boundaries. To the south was the flat and notorious Houston prairie and to the north was the rolling Piney Woods forest; to the west, the post oak savannah. Culturally, before European settlement the region lay between the coastal gatherers and the northeastern farmers. The region was sparsely occupied except along major waterways. Early settlers report Bidai Indians living along Spring Creek and the Brazos River. The Bidai are closely related to the Orcoquisac in Liberty County and to other Indains who inhabited the coastal prairies. Farther inland to the northeast

were the Caddo Indians whose agricultural practices may have diffused to the Orcoquisac shortly before European contact. With simple technology, north Harris County is not easy land to farm and we have no evidence that the Indians ever attempted it.

According to members of the Hooks family and inspection of aerial photographs, the land on which the airport was placed was poorly drained and had permanent lakes. As such it would have been uninviting for habitation and, indeed, one sees that all of the early homesteads were on high ground near the creeks. Just above the floodline, this high ground continues to be prime residential land, in spite of the sprawling subdivisions which are encroaching rapidly on the wetter interfluvial stretches (Figure 2).

One would not expect to find Indian sites on the airport property. In fact, the only Indian artifact known by Robert Hooks to have been found in the vicinity is an arrowhead which was uncovered along Willow Creek at the western edge of the Hooks property where a pipeline ditch had been dug in 1949. This substantiates the general pattern of finding such material along watercourses and suggests that dredging of the creek has probably [illegible] removed or buried all traces of Indian habitation. To the north, [illegible] (19[illegible]:33-36) reports Indian sites along Spring Creek and the [illegible] Indians near Huffsmith. Likewise the site of the present [illegible] Park on Spring Creek west of Tomball was an Indian site.

[illegible] Survey

[illegible] proposed extension is flat, [illegible], therefore, to examine the

entire property except where recent construction has covered the ground. The present airport is the chief recent disturbance.

My procedure was to drive by auto to the various pastures and walk the terrain looking for any trace of ancient habitation. The survey entailed only a superficial examination; I did not do any digging.

Nothing was revealed by this series of observations which had not been predicted by careful prior examination of the aerial photos and topographic maps. With the exception of the sweetgum grove which is discussed below, there is no reason to expect that extension of the airport will affect any cultural remains of historic significance. Neither aboriginal sites nor historically significant structures are present.

The Sweetgum Grove

This grove, which has been fenced off from adjoining pastures for some years, is believed by members of the Hooks family to have been an overnight campground for wagon trains heading toward Houston, or possibly along an east-west route. Robert Hooks has discovered traces of an old road in the woods west and north of his house and he thinks that some of the old roads shown on the 1920's topographic map are remnants of an east-west road that ran roughly from Tomball to Westfield (Figure 3). Local written histories seem not to mention the road.

At present the grove is a jungle-like tangle of vines, bushes and trees, predominantly sweetgum. I attempted a physical examination to see whether there were any traces of use on the trees since the ground is nearly out of reach owing to the dense vegetation. While I was examining

the trees, I noticed a distinct ridge flanked by two "ditches" running the length of the grove (i.e., north-south). As nearly as I could measure it, the distance from center of ditch to center of ditch is about 12 feet. The overall relief of ditch and ridge is about 2-3 feet. Without stripping away the vegetation, the description must remain imprecise.

At the south end of the grove at the fence line, the ridge is truncated and the track extends out into the pasture about 15 meters east of and parallel to the present fence line. The track shows clearly as a stripe of greener vegetation flanked by cattle paths. The track is about 8 feet across here. I was able to trace the track as far as the old slough which is now drained toward the east by a ditch (Figure 4).

To the north of the grove the track runs through a thicket just east of the fence line which runs to Boudreaux Road. The ridge-and-ditch structure seems to carry into this strecth; again the overall width is about 12 feet.

Along Boudreaux Road, the marsh has been contained to make a series of lakes on either side of the road so that the trail is lost at this point. It is probable that an old trail avoided the marsh and angled to the west as it approached the present Boudreaux Road.

The identification of the grove as a remnant of a road is based on the peculiar fortuitous preservation of the characteristic road ruts which wagons create in the absense of suitable paving. That these were preserved apparently is attributable to the fact that the grove has not been farmed; to the south the road is nearly obliterated whereas on the north side it is partly preserved as an embankment of the lake.

The grove stands out from a considerable distance and would have been more striking before forests had expanded. For travelers on the prairie, it might have been a natural stopping place because of the trees, availability of permanent water, and abundant grazing. Although the grove is dry, it is in the midst of marshy fields. The fact that the trees grow slowly if at all suggests that their roots may be waterlogged; sweetgums prefer well-drained soil. Although the trees are small, there are many more of them in the grove today than 40 years ago when the first aerial photo was taken (photos supplied by Charlie Hooks). Still the outline of the grove and the sizes of the largest trees have remained essentially constant.

The oldest photo shows a relatively open ground surrounded by trees. As such it would have been much more attractive as a campsite than it appears today.

Was the Grove a Wagon Camp?

There are two approaches to answering this question: historical and archeological. The former attempts to find written evidence of a camp, or circumstantial evidence that it might have been a camp. An archeologist seeks tangible remains of a camp in the ground. Either or both kind of search may be definitive and in combination they should produce dependable results.

Historical Evidence

In the time available, I was unable to conduct a thorough historical search although I was able to read rapidly half a dozen books, scan pamphlets and books on local history and quickly search 80 volumes of the

Southwestern Historical Quarterly for relevant information. In the company of Robert Hooks, I interviewed two older residents of the area who have lifelong familiarity with the property. Other informants remain to be questioned. I have searched no primary historical material such as diaries, letters or newspapers.

For purposes of discussion, I will assume initially that an east-west trail or road existed somewhere in the area. The earliest of these, the Atascosito Road linked Liberty (and thence via the Opelousa Road into Lousiana) with San Felipe on the Brazos. It is thought that this road crossed the San Jacinto River approximately where the bridge on Highway 1960 crosses Lake Houston today. The remainder of the route is uncertain although it is said that it crossed the Harrisburg-Washington-on-the-Brazos Road at New Kentucky (Miller, 1977:94). Since the Atascosito Road was established in the late 17th century and Washington-on-the-Brazos was settled in the early 19th century, considerable changes may have taken place in the specific route in consequence of settlement of the region. A recent pamphlet (HCHC 1977:8) reports that the road passed just south of Tomball. At present there is no single road which follows the route just mentioned from Liberty to Tomball to San Felipe; indeed it is notable that until the last decade there was no continuous road across northern Harris County from west to east.

For practical purposes the Atascosito Trail predated settlement of northern Harris County. After the 1830's, when land grants were made and especially following the Battle of San Jacinto, the area began to receive settlers and the major trails thereafter were in the direction of Houston-Harrisburg. This pattern can be seen clearly today in the spoke-like roads

emanating from Houston. That these roads were laid out earl-- in history is indicated by the fact that they are essentially straight for long stretches. These roads were maintained to ship goods into Houston from the farms in outlying areas. With the advent of railroads to this part of Harris County between 1873 and 1906, the roads fell into disuse and new trading centers such as Tomball, Huffsmith, Spring and Westfield were established. By the 1920's trucks had begun to carry goods into Houston, in part replacing the old wagons and the newer trains. Still, North Harris County remained sparsely settled and undeveloped.

Mrs. Cora Bonds, a woman of 82 years who lived at the Hooks property as early as 1924 and whose husband (deceased but would be 95) was born in the house just to the west, maintains that a trail called "Cheatham" ran past the gum grove and headed southeast toward Stuebner-Airline past a house just south of the present airport runway. She says that her husband and relatives told her that Sam Houston and his army had camped at the grove on their way to San Jacinto.

I have been unable to find any reference to a "Cheatham" Trail or any other specific information that Sam Houston passed the grove. Many people believe that Houston's route followed the present Route 149, West Montgomery Road (HCHC 1977:26).

Mr. Charles Mahaffey, lifelong resident of the area, herded cattle as a young man where the airport is today. He was unable to recall seeing any trace of a trail past the gum grove. He did, however, say that his father was road foreman when the Stuebner-Airline Road was built in 1900-01 and that it had followed an old trail. He also mentioned a campground along this trail at Greens Bayou. The Stuebner-Airline Road served the old Willow community at Willow Creek as well s other residents along

the creek, before Huffsmith, Tomball and other settlements to the north were established along railroad lines.

As early as 1848, businessmen in Houston began improving a road to Montgomery County, probably to Montgomery City. It is important to note that roads connecting North Harris County with Houston were an essential aspect of development of the area from 1850 to the present. Roads running west-east were not developed systematically with capital investment. The 1920 topographic sheet shows clearly how difficult travel was in that direction.

The evidence, insubstantial as it is, suggests that a wagon camp at the sweetgum grove would have been along a trail that traveled north-south. In fact, owing to the pattern of settlement in the 19th century, a road most likely would have turned toward the northwest at about Willow Creek. The evidence further suggests that such a trail would have been in use between about 1850 and 1920 and that it probably followed the general Stuebner-Airline route.

Geographic Evidence

I have been unable to find a history of wagoneering or teamstering in this part of Texas, but some books, such as Dr. John Lockhart's Sixty Years on the Brazos, have useful information. Lockhart writes that as early as the 1840's cotton was being shipped into Houston via ox trains and that the trip was slow, in part because the oxen were driven only 5 or 6 hours a day. Another writer, Dr. Ferdinand Roemer makes clear why travel by ox team was slow. He points out that the prairie, being poorly drained, was often boggy, making slow-going at certain times of the year. Oxen are naturally slower moving than mules which were used on drier lands but they are stronger and have broader feet which resist sinking into mud.

Further, oxen can subsist entirely on the grass found locally. Roemer estimates that oxen traveled 10 to 15 miles per day. He also mentions that wagon camps were often in groves of trees where fuel and shelter could be found. Finally, McComb (1969:31) cites a number of newspaper articles which graphically describe the problems of early transport into Houston:

> The Morning Star noted in 1942, for instance, that although teams arrived daily, they could travel only six to eight miles per day. They had to wait at flooding streams eight to ten days, and one wagon from Independence had been so detained for thirty days. Wagons sank one to two feet in mud in bad spots and at times rain inundated the prairie. In 1846, sheets of water, two to three feet deep and four to five miles wide, covered the Richmond Road.

It should be noted that the gum grove at the airport sits out into the prairie well away from the nearest trees. In this location it is an obvious landmark and provides the requisites of a good campsite: shelter, fuel and abundant grazing in the vicinity on land that was not farmed until the middle 20th century.

If we consider the location of the grove in relation to other campsites we find that it is appropriately placed for ox teams. Assuming a trail along the Stuebner-Airline route, with downtown Houston at Buffalo Bayou as the terminus, the Greens Bayou camp is some 13 miles distant; the gum grove is 11 to 12 miles farther; and New Kentucky is another 13 miles. These campgrounds may represent maximum stages in good weather. During wet weather intermediate campgrounds would have been used. The grove is approximately where one would predict it to be, assuming travel by teams of oxen to and from Houston.

The Archeological Problem

It would be possible to determine whether the sweetgum grove has been used as a campsite for wagon trains, and when. The identification and dating of the campsite require sufficient artifacts specific to wagoneering and capable of being dated.

Archeological investigation would require mowing and cutting of all vegetation close to the ground, preferably followed by grazing or raking to remove all litter from the ground. The end of the growing season is the ideal time for this work. Following clearance, the ground should be searched with metal detectors in such a way that any pattern of distribution of artifacts could be discerned and recorded. Following preliminary analysis of this material, excavations should be made in appropriate places to enlarge the collection of artifacts and escpeially to recover non-metallic material.

If suitable artifacts can be recovered, it might be appropriate to prepare an informative pamphlet and construct a display at the airport or at the grove.

Recommendations

During development of the airport, care should be taken to avoid damage to the grove. It clearly has local historical significance as a legendary wagon train campsite and it may have been associated with San Houston. Apart from these historical associations, the grove is a relict of 19th century vegetation, an "island" of trees in the midst of a prairie. The chief interest, however, is in determining whether the site is what local tradition holds it to be.

If there is tangible evidence of an old wagon trail in the sweetgum grove it should be preserved as an unusual and important record of the development of North Harris County. The fact that the history of wagoneering has yet to be written is perhaps sufficient justification in itself to preserve these traces. Inasmuch as there is doubt about the grove, it ought to be systematically and carefully examined for historic artifacts and any other evidence that will provide a definitive identification. If material is found, additional historical research should be undertaken to attempt to put the artifacts in their correct historical context. The archeological work is relatively straightforward but the historical research may be very time-consuming; consequently I recommend that the archeology be done first.

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Frank Hole

Frank Hole
26 May, 1978

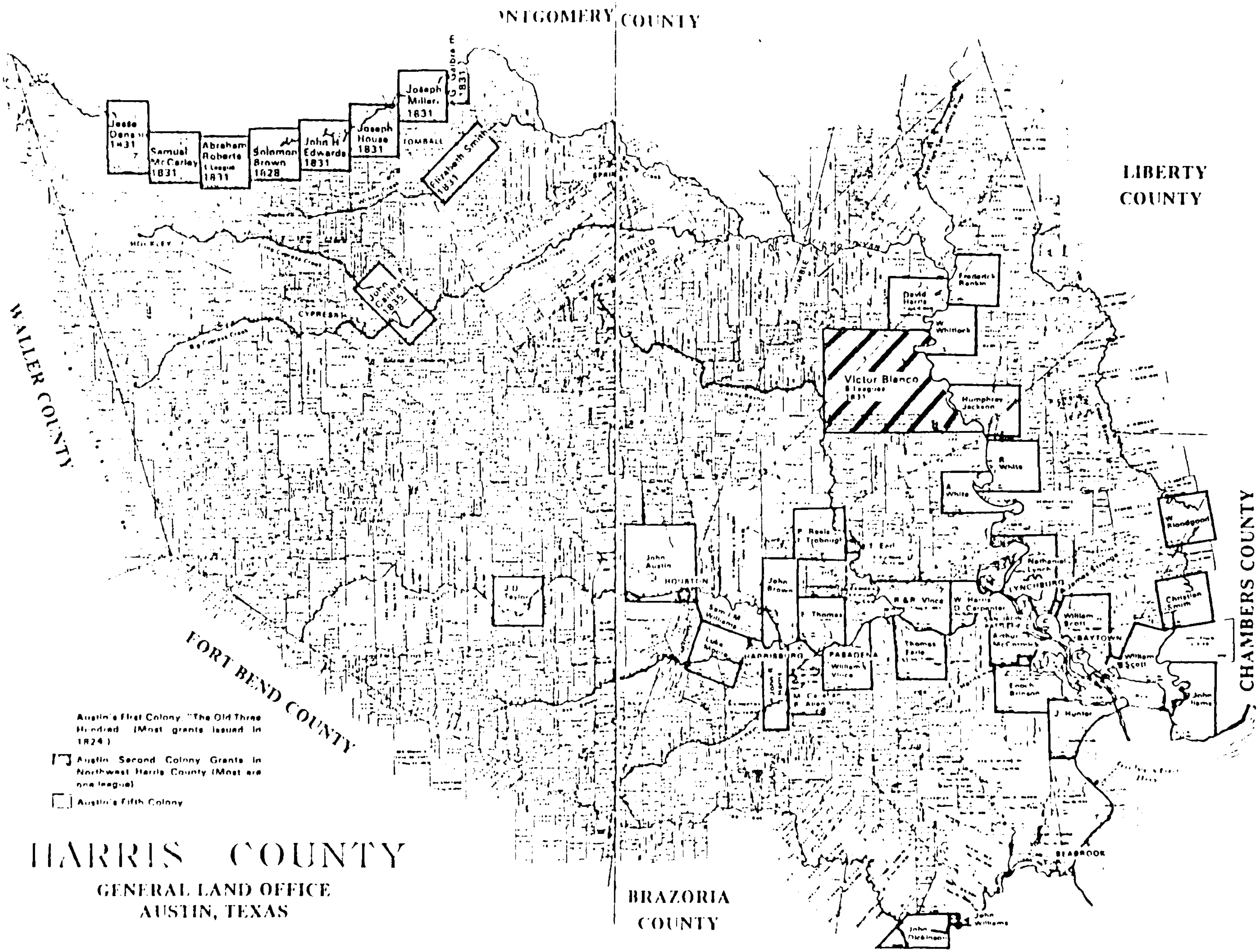


Figure 1. Location of Elizabeth Smith league of 1831, the site of the present David Wayne Hooks Memorial Airport. From Heritage of North Harris County, 1977.

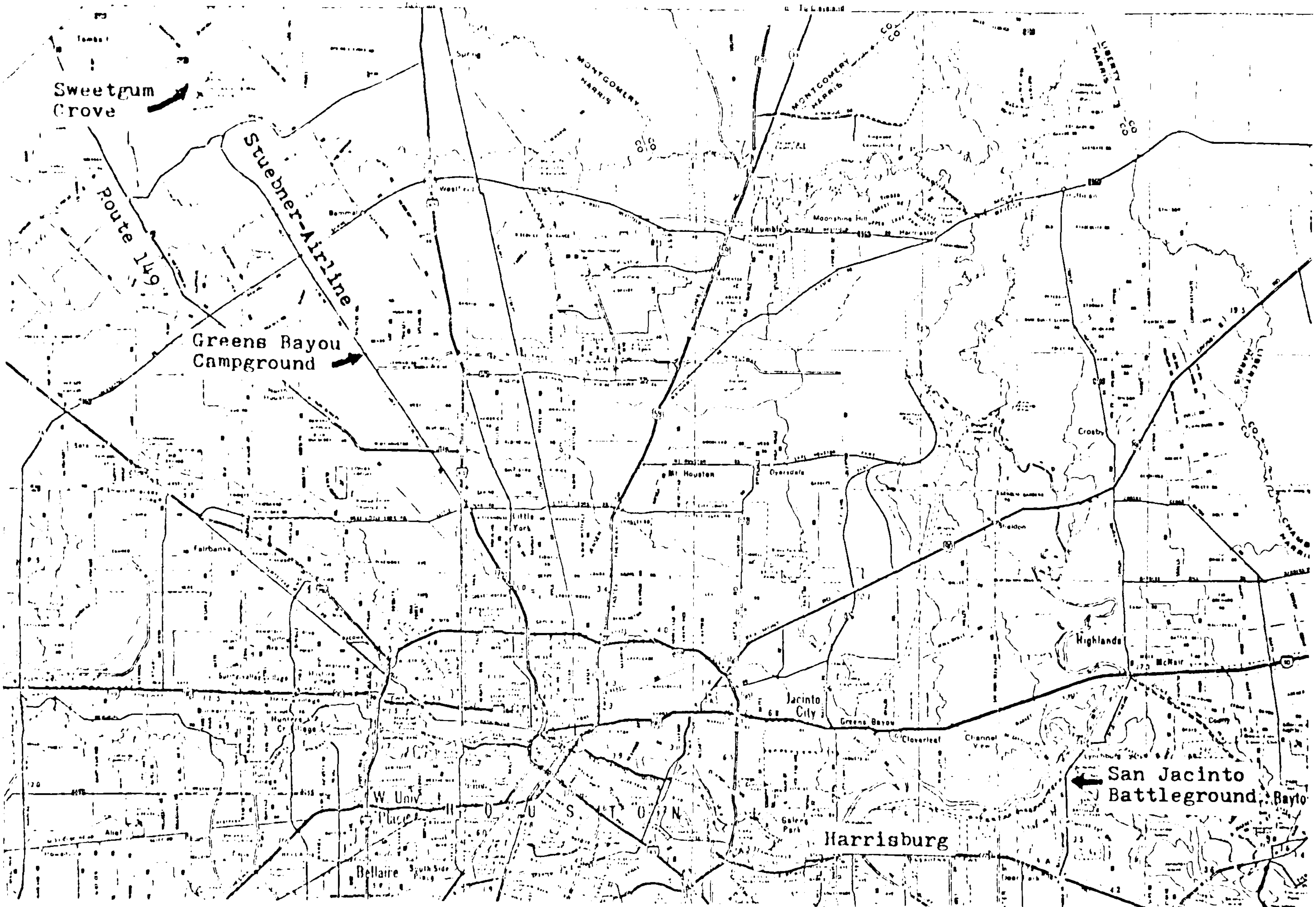
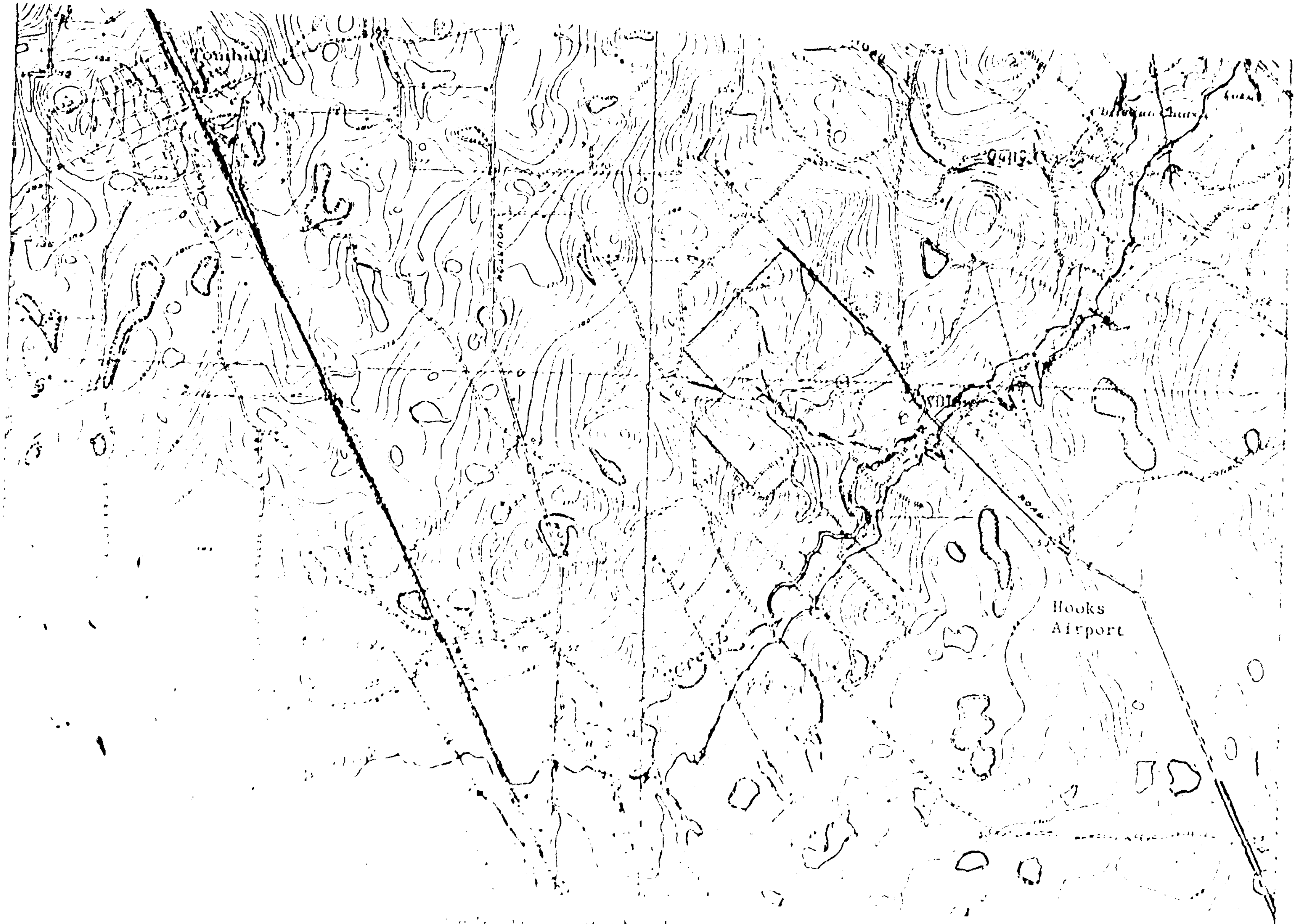


Figure 2. Houston region showing location of Hooks Airport in relation to Harrisburg and the routes from Montgomery and North Harris Counties into Houston.



... showing the roads and trails in ... Memorial Airport.

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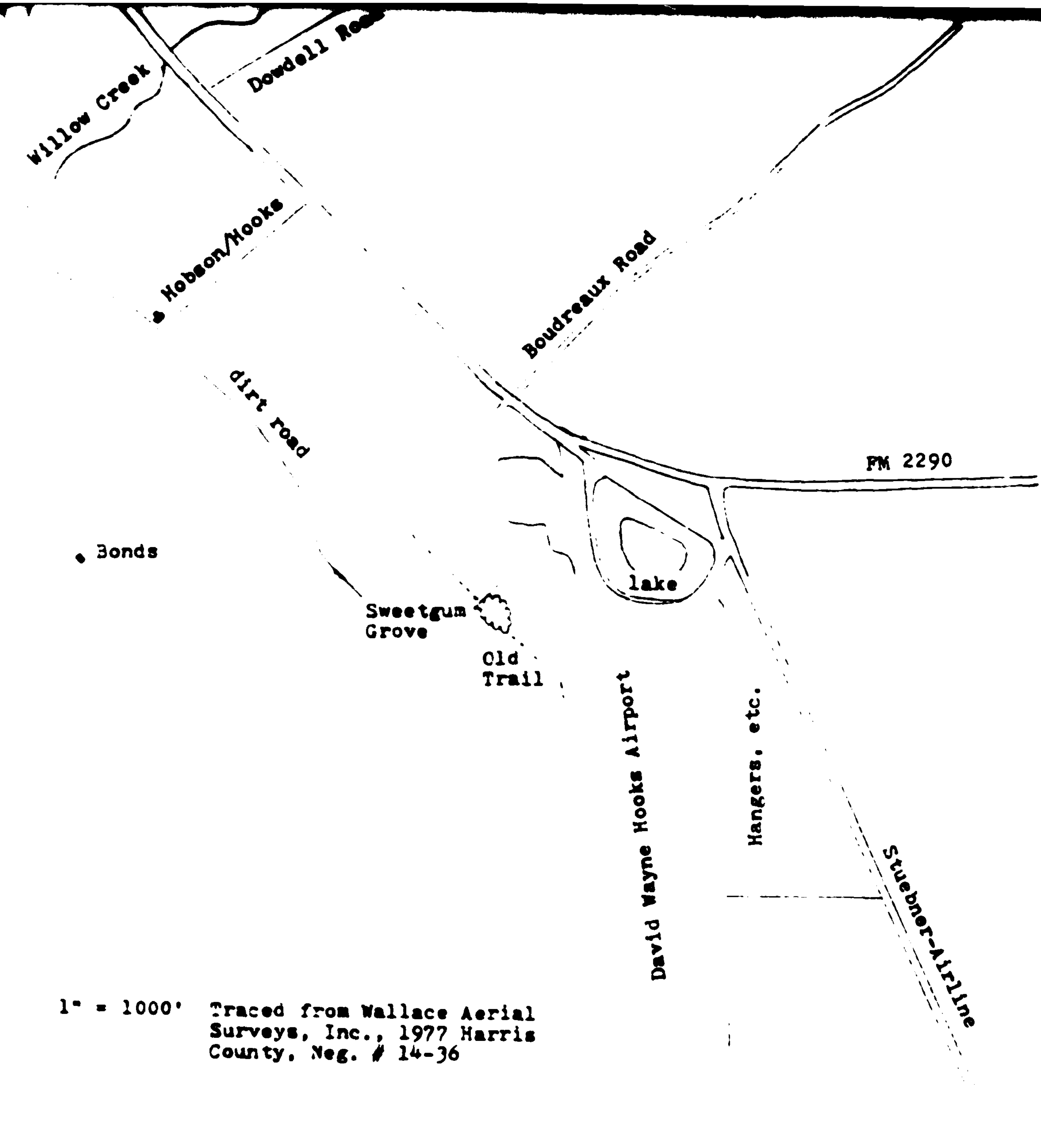

Figure 4. Location of Sweetgum Grove
and Old Trail

APPENDIX B

Job No. 2280-010

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

PROPOSED DEVELOPMENT OF DAVID WAYNE HOOKS MEMORIAL AIRPORT HARRIS COUNTY, TEXAS

December 1978

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As a result of 1) the significant growth in general aviation in Harris County, 2) the potential need for public ownership of a general aviation airport, and 3) the requirement for long-range planning to better define the nature of facilities to satisfy projected aircraft demand, the Harris County Commisioners' Court made application for and was offered a grant from the Federal Aviation Administration (FAA) for the purpose of developing an Airport Master Plan for the northwestern area of Harris County. The county formally accepted the grant on September 5, 1977 and engaged Turner Collie & Braden Inc. to prepare the Master Plan.

As an integral part of the planning process, this Environmental Impact Assessment Report (EIAR) focuses on the anticipated impact of public acquisition and expansion of David Wayne Hooks Memorial Airport (Hooks) as the recommended site within the northwestern region of the county for the general aviation facility. Mr. Charles G. Hooks, Jr. owns Hooks Airport which is located on Stuebner Airline Road near its intersection with Spring Cypress Road. Exhibit 1 is a vicinity map of the area.

Hooks currently has a primary 5,340-foot long, 110-foot wide runway and a parallel secondary 2,500-foot long, 40-foot wide runway. In addition, a seaplane landing area 2,600 feet long and 100 feet wide is located at Hooks. Existing based aircraft are shown in Table 1. Over the next 20 years based aircraft and general aviation operations are forecasted to increase to the

levels shown in Tables 2 and 3 respectively, necessitating expansion at Hooks to include the facilities shown in Table 4. Development will cause certain environmental effects that are addressed herein. This EIAR meets the requirements of the National Environmental Policy Act of 1969, guidelines of the Council of Environmental Quality, and FAA order 1050.1B, "Policies and Procedures for Considering Environmental Impacts."

TABLE 1 - CURRENT BASED AIRCRAFT
D.W. HOOKS MEMORIAL AIRPORT

Type	Number
Single Engine	210
Multi-Engine	
Piston	47
Turbo Prop	5
Turbo Jet	3
Rotorcraft	12
TOTAL	277

TABLE 2 - BASED AIRCRAFT FORECAST
D.W. HOOKS MEMORIAL AIRPORT

	1982	1987	1997
Single Engine	231/252	260	265
Multi-Engine			
Piston	56/61	68	77
Turbo Prop	13/15	24	36
Turbo Jet	15/16	30	51
Rotorcraft	15/16	18	21
TOTAL	330/360	400	450

TABLE 3 - ANNUAL OPERATIONS FORECAST
D.W. HOOKS MEMORIAL AIRPORT

	1982	1987	1997
Single Engine	121,275/132,300	136,500	139,125
Multi-Engine			
Piston	23,240/25,315	29,240	34,650
Turbo Prop	6,240/7,200	11,640	17,640
Turbo Jet	6,600/7,040	13,500	24,225
Rotorcraft	14,250/15,200	17,100	19,950
TOTAL	171,605/187,055	207,980	235,590

TABLE 4 - AIRPORT DEVELOPMENT SCHEDULE
D.W. HOOKS MEMORIAL AIRPORT

First Phase Improvements (1978-1982)

1980

- Overlay existing airport pavement where needed.
- Construct general aviation hangars to accommodate 47 additional aircraft.
- Construct apron area and runway access taxiway.
- Install security fencing.
- Install visual aids.
- Extend taxiway parallel to existing runway.
- Demolish existing barn.
- Remove existing taxiway pavement and road where indicated on Airport Layout Plan.
- Acquire undeveloped adjacent land and obtain easements, approximately 752 acres for new runway and clear zones.
- Fill and level lake to provide runway safety area.

1981

- Construct general aviation hangars to accommodate 28 additional aircraft.

1982

- Construct general aviation hangars to accommodate 33 additional aircraft.

Second Phase Improvements (1983-1987)

- Construct 6,000-foot parallel runway with associated taxiways.
- Install precision approach navigational and visual aids.

TABLE 4 (Cont'd)

- Construct general aviation hangars to accommodate 35 additional aircraft.
- Construct crash, fire, and rescue building.

Third Phase Improvements (1988-1997)

- Construct general aviation hangars to accommodate 50 additional aircraft.

This section addresses the expected environmental impacts expected to result from current and forecasted aviation activities at Hooks airport. The majority of the property surrounding Hooks is undeveloped, lightly populated farm land; however, some residential development is present in the area. Consequently, the existing environmental quality is good to excellent proximate to the airport.

Environmental effects of development covered in this section include:

- II-1 Noise
- II-2 Air Quality
- II-3 Water Quality
- II-4 Social Impacts
- II-5 Induced Socioeconomic Impacts
- II-6 DOT Section 4(f)
- II-7 Historic and Archeological Sites
- II-8 Flood Hazard Evaluation
- II-9 Considerations Relating to Wetlands and Coastal Areas
- II-10 Energy Supply and Natural Resources Development
- II-11 Construction Impacts
- II-12 Wildlife and Fowl
- II-13 Impacts Relating to Endangered and Threatened Species of Fauna and Flora
- II-14 Light Emissions

II-1 Noise

The January 1978 edition of the FAA's Integrated Noise Model (INM) was used to obtain noise contour data for the anticipated mix of operations at Hooks for 1978, 1982, 1986, 1987, and 1997. The Day-Night Level (Ldn) in decibels was the metric chosen for the contour envelopes. Ldn is the average noise level integrated over a 24-hour period. Appropriate weightings are applied for noise occurring in the daytime and nighttime periods. For example, a ten decibel penalty is applied for nighttime operations. The 65 Ldn level is approximately equivalent to noise levels which might be expected in a noisy urban environment. Studies of noise annoyance conducted by several agencies and reported by the Environmental Protection Agency (EPA)[1] indicate that noise levels beyond that range may result in significant complaints from area residents. The 75 Ldn contour approximates the downtown area in a noisy metropolis.

A review of the noise contour plots contained in Exhibits 4 through 8 reveals that for 1978 and 1982 only a 65 Ldn contour appears, due to the lower number of aircraft operations in those two years. The 1978 contour (Exhibit 4) is confined to the existing airport boundaries; however, the increase in operations

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[1] Information on Levels of Environmental Noise Required to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA 550/9-74-004, March 1974.

forecasted for 1982 causes the envelope to extend off the southern airport boundary about 1,600 feet and off the northern boundary 900 feet. To the north and south the overlap is into undeveloped farm land.

Although 1986 was not specified as one of the time frames for this report, 1986 is the year at which Hooks is expected to reach its operational capacity if no new runway is built. Thus, the 1986 noise contour presents the "do nothing" alternative that can be used to compare the impacts of noise both with and without a second parallel runway. Review of the 1986 noise envelope shows that two contours appear for 1986--75 Ldn, closest to the runway, and 65 Ldn. The 75 Ldn stays within the existing airport property line while the 65 Ldn extends outside by 3,600 feet to the south and 1,900 feet to the north.

In 1987, the addition of a parallel runway, coupled with increased operations, causes a significant widening and lengthening of the 65 Ldn contour. Although the northernmost portion of the contour stays within 700 feet of the property line for Hooks, the southernmost contour lies some 7,200 feet outside the property line. The land inside the contour presently consists mainly of undeveloped farm land; however, easements or land acquistion would be necessary to prevent encroachment into the noise sensitive area of the runway by residential, business, or recreational development. The 75 Ldn runs 300 feet to the south of the existing

airport boundary, while to the north the contour stays inside the current property line. Since the 75 Ldn line remains so close to the proposed 6,000-foot runway, the contour would remain within the expected airport boundaries, assuming additional land is acquired in accordance with Table 4.

Exhibit 8 presents the 1997 noise situation. The 65 Ldn has again expanded and widened. The southernmost contour extends past Spring Cypress Road about 8,000 feet from the existing runway. To the north, the 65 Ldn lies 1,800 feet off the airport site. The 75 Ldn is 3,500 feet to the south of the Hook's boundary and stays inside the property line to the north.

Table 5 is a summary of areas enclosed by the noise contours for each year included in this EIAR. The principal reason for the progressive increase in bounded areas is the increase in the forecasted number of aircraft operations for each year.

TABLE 5 - SUMMARY OF AREA ENCLOSED BY NOISE CONTOURS
D.W. HOOKS MEMORIAL AIRPORT

Year	Acres Enclosed 65 Ldn		Acres Enclosed 75 Ldn	
	With New Runway	Without New Runway	With New Runway	Without New Runway
1978	102	102	0	0
1982	173	173	0	0
1986	275	275	32	32
1987	602	275	57	32
1997	806	275	77	32

II-2 Air Quality

The impact on the surrounding air quality of the increased operations at Hooks will not be significant with the exception of air pollution that would come about during construction of the new runway. Construction impact on air quality can be minimized by following quidelines set forth in FAA Advisory Circular 150/5370-7, "Airport Construction Controls to Prevent Air and Water Pollution."

Data shown in Table 6 compare the impacts from the proposed improvements to the Ambient Air Quality and National Air Quality Standards. Review of the data, in fact, demonstrates the minimal effect of Hook's aircraft on the surrounding air quality. The technique used to derive Table 6 is described in Appendix B.

Although increased surface traffic would be expected in the immediate vicinity of Hooks Airport over the periods of this report, the change in air quality on an areawide basis due to the automobiles will not be significant. Presumably, the majority of persons basing aircraft at Hooks are already operating their private vehicles somewhere in northwestern Harris County. The incremental impact on air quality of these persons driving to Hooks to fly is considered to be negligible in comparison to their normal daily driving within the study area.

II-3 Water Quality

The forecasted increase in operations at Hooks is expected to create slightly greater usage of the existing sanitary treatment facilities, which consist of a septic tank and drain field. This increased usage will not significantly change groundwater quality in the surrounding area. During the construction period the contractor will be required to comply with directives of the project engineers and FAA Advisory Circular 150/5370-7, "Airport Construction Controls to Prevent Air and Water Pollution." Little additional surface runoff due to the construction of the parallel runway in 1987 is anticipated.

II-4 Social Impacts

No socially adverse impacts will occur as a result of development at Hooks. Easements can be used to prevent encroachment by incompatible land-use regions into noise-sensitive areas in 1987 and 1997 so that no displacment of people or businesses or disruption of established communities should occur. No modification of existing surface traffic patterns, with the exception of the widening of Stuebner Airline Road proximate to Hooks, will occur.

II-5 Induced Socioeconomic Impacts

Since the air traffic at Hooks will not include air carriers, little secondary economic expansion will occur near Hooks as a result of the proposed development. Also, Hooks presently exists

as a viable airport so no shifts in population growth or forced movement of people will occur. Some slight economic growth in the area will likely result as businesses such as fixed base operators and flying schools increase their scope of activities to handle maintenance of a greater number of based aircraft and higher demand for flight instruction respectively. Additional economic development that may occur off the airport site is not clearly attributable to the airport expansion. As noted above, no air carrier service is forecasted for Hooks, so the vast majority of the air traffic will be business oriented. This type of operation will provide minimal economic stimulus to the area itself. The major economic growth in northwestern Harris County will occur as a result of the continual growth in resident population and not because of expansion of Hooks Airport.

II-6 <u>DOT Section 4(f) - Public Lands</u>

The use or acquisition of public lands will not occur under the planned development at Hooks. DOT Section 4(f) is not applicable.

II-7 <u>Historical and Archeological Sites</u>

Dr. Frank Hole of the Rice University Department of Anthropology, under contract to Turner Collie & Braden Inc., conducted a survey of the Hooks site to determine the presence of any objects

of historical, architectural, archeological, or cultural significance. Dr. Hole's investigation revealed that a sweetgum tree grove located northwest of the existing runway may have considerable historical importance. Dr. Hole believes the grove to be an overnight wagon train campsite for travelers in the nineteenth century. In addition, Sam Houston and his army may have camped at the grove on the way to San Jacinto. In any event, the development of Hooks Airport will be planned to preserve the sweetgum grove. No other sites of historical, archeological, or cultural significance will be affected by expansion at Hooks. Dr. Hole's report is Appendix C hereto.

II-8 Flood Hazard Evaluation

Review of the flood plain information for Willow Creek, which is the only major stream in the vicinity of Hooks, indicates that the proposed runway improvement will not encroach upon Willow Creek's[2] flood plain. No flood hazard problems are anticipated as a result of expansion of Hooks.

II-9 Considerations Relating to Wetlands and Coastal Zones

Development of Hooks Airport will not include the utilization of wetlands or coastal zones or affect any land or water covered by a state coastal management program.

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[2] Flood Plain Information, Spring and Willow Creeks, Houston Metropolitan Area, Texas, Prepared for Harris Soil and Water Conservation District, Houston, Texas, by the U.S. Army Corps of Engineers, Galveston District, Galveston, Texas, June 1972.

II-10 Energy Supply and Natural Resources Development

The effect on energy supply and natural resources development by expansion at Hooks is not considered to be a major environmental impact. However, construction to meet the requirements of Table 4 will involve expenditure of energy in the form of gasoline and electricity. Over the longer term the expanded operations posture expected will increase aircraft fuel consumption. Table 7 depicts the projected annual aircraft gasoline usage. Increased usage of the runways will also create a need for additional airside maintenance activities to support both the runways and the aircraft. These maintenance functions involve expenditure of energy resources.

Electrical consumption at Hooks to facilitate landside activities is not expected to increase significantly over the next 20 years. As noted earlier, there will be no air carrier flights at Hooks. Accordingly, no "terminal type" functions will be accomplished (such activities would include among others baggage handling, ticketing, or security checks).

However, the newly constructed hangars will likely require additional electrical power. In general, the increased consumption of energy at Hooks for landside facilities is not considered significant in comparison to current usage.

The reader should note that natural gas wells exist at the Hook's site and are used to provide natural gas for the airport.

TABLE 7 - PROJECTED AIRCRAFT FUEL CONSUMPTION
D.W. HOOKS MEMORIAL AIRPORT

Year	Aircraft Fuel Consumption (Gallons) Without New Runway	Aircraft Fuel Consumption (Gallons) With New Runway
1982	1,720,000	---
1986	2,260,000	---
1987	2,260,000	2,400,000
1997	2,260,000	3,660,000

Notes:

1. Airport will reach capacity level operations by approximately 1986. Therefore, fuel consumption without the new runway will remain constant after 1986.

2. New runway will not be available until 1987.

Airport modification will be planned to leave these gas wells intact and operational.

II-11 Construction Impacts

All construction envisioned for Hooks will be confined to the airport site (inclusive of land acquisitions in the 1983-1987 time frame). Unavoidable impacts from construction equipment include:

- Noise on Site
- Solid Waste
- Consumption of Building Materials and Energy
- Air Quality Degradation

Contract documents will contain provisions to minimize the effects of the airport improvements. In addition, all work will be done in accordance with FAA Advisory Circular 150/5370-7, "Airport Construction Controls to Prevent Air and Water Pollution."

II-12 Wildlife and Waterfowl

Minimal impact upon wildlife or waterfowl will result from runway improvements at Hooks. Correspondence with the Texas Parks and Wildlife Department is contained in Appendix D.

II-13 Impacts Relating to Endangered and Threatened Species of Fauna and Flora

No endangered and threatened species of fauna and flora exist at the airport site.

II-14 Light Emissions

The addition of a Medium Intensity Approach Lighting System (MALS) will be necessary to support the approaches to runways 17R

and 35L. The approach to runway 17R will include Runway Alignment Indicator Lights (RAIL). Additional details of the system's lighting components are shown in Table 8. Basically, the MALS consists of medium intensity nonflashing lights. The RAIL has five sequenced flashers located 1,600 feet beyond the threshold of the runway and successive units located at each 200-foot interval out to 2,400 feet from the runway threshold. These lights flash in sequence towards the threshold at the rate of twice per second.

Runway End Identifier Lights (REIL) will also be installed at either end of both runways. The REIL system consists of two synchronized flashing lights located near the runway threshold to provide rapid and positive identification of the approach end of the runway.

The REIL and MALS systems create the light emissions that could have adverse environmental impact on the area surrounding Hooks. The layout of the lighting systems for the airport is shown on the Airport Layout Plan (Exhibit 3). Since the land surrounding Hooks is mainly undeveloped farm land, annoyance from light emissions is expected to be minimal.

TABLE 8 - SPECIFICATION DATA FOR LIGHTING EQUIPMENT
D.W. HOOKS AIRPORT

System	Beam Angle (Degrees)	Intensity (Candelas)	Color	Flashing Sequence
Medium Intensity Nonflashing Approach Lights (MALS)	25	4200	White	---
Runway Alignment Indicator Lights (RAIL)	360 Horizontal 2-10 Vertical	High-5000$\pm$2000 Low-700$\pm$200	White	2 per second
Runway End Identifier Lights (REIL)	360 Horizontal 2-10 Vertical	High-5000$\pm$2000 Low-700$\pm$200	White	2 per second

Notes:

1. Sources for MALS:

   a. FAA Advisory Circular AC 150/5340-14B, Economy Approach Lighting Aids, Appendix 1, page 3.

   b. General Electric Lamp Division Specification for PAR 38 Spotlight, 150 Watt, 2000-hour rated life at 120 volts.

2. Source for RAIL and REIL: FAA Advisory Circular AC 150/5340-14B, Economy Approach Lighting Aids, Appendix 1, page 22.

3. For RAIL and REIL systems, the effective intensity for the low intensity position at zero degrees horizontal shall not exceed 200 candelas.

III-1 Construction Impacts

As noted in the previous section, unavoidable environmental impacts while construction is underway at Hooks include:

- Noise
- Degradation of Air Quality due to Operation of Heavy Equipment
- Increased Solid Waste
- Consumption of Building Materials and Energy

Some increased runoff at the site will result with the addition of new runway. The above impacts can be minimized with proper planning in both the design and construction phases of the project. The design and construction agents will comply with the provisions of FAA Advisory Circular 150/5370-7, Airport Construction Controls to Prevent Air and Water Pollution.

III-2 Noise

The increased amount of noise is the result of expanded operations at Hooks over the next twenty years. In order to lessen the adverse effects of noise, persons can be notified of the existence of the noise-sensitive areas proximate to the airport. Since the vast majority of the property near Hooks is undeveloped, adequate planning can prevent encroachment into noisy areas by potential residences or businesses. Where the projected noise pattern affects existing noise-sensitive areas, owners of these properties can lessen impact through the addition of acoustical

insulation. In addition, aircraft using Hooks can utilize adjusted flight patterns or schedules that minimize noise effects. The reader should also note that the FAA INM used to forecast the future noise impacts of this report is limited somewhat because only noise for currently existing aircraft are included in the data base. In order to comply with Federal Aviation Regulation Part 36 future aircraft will be quieter. Thus, the noise envelopes depicted herein are likely somewhat exaggerated from the actual conditions that will exist in 1982, 1986, 1987, and 1997.

III-3 Light Emissions

The MALS with RAIL and REIL produces some adverse impact during operation. Although no annoyance would be expected if the lights were installed at this time due to the undeveloped nature of the land surrounding Hooks, some problems could occur as that land becomes occupied in the future. Comprehensive developmental planning will be necessary to minimize the adverse effects of light emissions.

The only alternatives considered to be technically feasible, economically justifiable, and environmentally sound for Hooks Airport included:

IV-1 - Expand the airport by addition of 1) a 6,000-foot parallel runway, and 2) supporting facilities to accommodate forecasted demand.

IV-2 - Do nothing. Retain the existing runway configuration, thereby reaching capacity level operations in the mid-1980's.

The scope and type of operations forecasted for Hooks simply do not justify a more elaborate runway scheme that would provide additional alternatives.

IV-1 Expand and Improve Hooks Airport

Under this alternative, Hooks Airport will acquire the additions indicated in Table 4. Construction of these facilities, in particular the new runway with its associated approach lighting system, will have some adverse consequences. Expansion involves expenditure of funds and resources. Also, slight degradation of air and water quality will occur. Noise generated by aircraft using the two runways will be significantly greater with the new parallel runway than without it. All of these effects are described in detail elsewhere in the EIAR.

Benefits derived from the proposed development include:

- Increased capacity of the airport to handle the forecasted demand.
- Adequate runway length in the event Hooks is even further expanded to include other types aircraft.

- Convenience to users since they presumably will not have to drive as far to reach their aircraft.

- Flexibility for noise abatement procedures.

- Increased safety for pilots due to expanded navigational and visual aids.

IV-2 Do-Nothing

This alternative assumes Hooks will remain open, but will undergo none of the development outlined in Table 4. The "Do-Nothing" approach allows for progressive increases in numbers of flights up to the airport's predicted capacity which is 201,600 operations per year. In comparison to the previous alternative, this approach is environmentally attractive for the following reasons:

- Operational capacity of the airport will be reached by 1986. Accordingly, the annual impact on air and water quality and noise will remain at about the same level for years beyond 1986.

- No irretrievable commitment of resources with accompanying noise, air pollution, and solid waste is involved.

Detrimental affects of this alternative include:

- The do-nothing approach would fail to accommodate the forecasted needs after 1986. Some users would have to be routed to other local airports.

- Runway length limits aircraft types that can use Hooks.

- The operational scope of the airport is limited to a nonprecision approach capability.

IV-3 Summary

The do-nothing alternative is considered to be the most environmentally favorable alternative discussed herein. The adverse environmental impacts are minimal, especially in light of the irretrievable commitment of resources associated with the expansion of the airport.

SECTION V - RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The short-term losses of the proposed development at Hooks include those associated with construction. These impacts have already been discussed fully. The short-term environmental impacts are minimal; but, they greatly broaden the future operations available at Hooks. For example, the expansion allows for 1) progressive operational increases for the next 20 years, 2) increased safety through additional navigation and visual aids, 3) enhanced flexibility for noise abatement, and 4) greater convenience to airport users.

SECTION VI - IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

With the exception of energy, proposed development at Hooks involves no commitment of limited sources or types of material. Expansion will somewhat curtail the range of beneficial uses of the environment proximate to Hooks because the land that is acquired to support the new facilities will be committed to uses compatible with airport activities.

This EIAR has attempted to describe those environmental impacts associated with comtemplated expansion at David W. Hooks Memorial Airport. The major impacts of such development include:

- Increased Noise
- Light Emissions from Runway Lighting System
- Increased Aircraft Fuel Consumption

Minor impacts to air and water quality are also expected if the development is undertaken.

In general, the negative environmental impact associated with expansion is significant. Considerable irretrievable resources will have to be committed in order to increase the capacity at Hooks. The do-nothing alternative, even though it results in a facility that will be unable to fully handle projected demand by the mid-1980's, is more environmentally attractive.

EXHIBITS

Internship Report Note: The exhibits that normally would have followed this page are identical to those used for the Interim Report for Site Selection and are incorporated with that document.

APPENDIX A - BIBLIOGRAPHY

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APPENDIX B - AIR QUALITY

Internship Report Note: This Appendix is identical to the one included with the Interim Report for Site Selection. Accordingly, Appendix B is <u>not</u> reproduced here.

APPENDIX C - CULTURAL RESOURCES ASSESSMENT

Internship Report Note: This Appendix is identical to the one included with the Interim Report for Site Selection. Accordingly, Appendix C is not reproduced here.

APPENDIX D - CORRESPONDENCE

Texas Historical Commission
Box 12276, Capitol Station
Austin, Texas 78711
Truett Latimer
Executive Director

March 23, 1978

Ms. Carol Batie
Turner Collie & Braden Inc.
P.O. Box 13089
Houston, Texas 77019

Re: Proposed Airport Projects: David Wayne Hooks and Lakeside
Harris County, Texas

Dear Ms. Batie:

In response to your request concerning the above-referenced undertaking, we have examined the maps and environmental information sent to this office. We conclude that, because of the high likelihood of significant cultural resources being found in the area, the project site must be surveyed by a professional archeologist. To accomodate your need in finding an appropriately trained specialist to perform the survey, we are sending along a list of professionals that are capable of performing this type of service. Upon completion of the survey and receipt of the subsequent report, we will comment on the project's effect on cultural resources.

Your attention to this matter is appreciated. If we may be of further service, please advise.

Sincerely,

Truett Latimer
State Historic Preservation Officer

By [signature] for

Alton K. Briggs
Director
Cultural Resource Management

AKB:la

TE ,AS
PARKS AND WILD'LIFE DEPARTMENT

HENRY B. BURKETT
EXECUTIVE DIRECTOR

4200 Smith School Road
Austin, Texas 78744

March 27, 1978

Ms. Carol Batie
Turner Collie & Braden, Inc.
Post Office Box 13089
Houston, Texas 77019

Re: Lakeside and David Wayne Hooks Memorial Airports Studies

Dear Ms. Batie:

In response to your letters dated March 9, 1978, we have reviewed your requests concerning habitat interference by your project on endangered species. We offer the following comments.

Neither of the two study areas involve known areas of habitat involvement by threatened or endangered species. The Lakeside Airport expansion project is perhaps two (2) miles from suitable Houston toad habitat in upper Addicks Reservoir. Also, at Lakeside there is a possibility of an alligator occasionally wandering northward from South Mayde Creek.

If we can be of further assistance, please contact us.

Sincerely,

Henry B. Burkett

HENRY B. BURKETT
Executive Director

HBB:MM:lmw

APPENDIX C

Turner Collie & Braden Inc.

P.O. Box 13089
Houston, Texas 77019
5757 Woodway
(713) 780-4100
Telex 77-4185

October 9, 1978

U.S. Department of Transportation
Federal Aviation Administration
Office of Airports Programs
Washington, D.C. 20591

Gentlemen:

In Technical Report FAA-AP-77-1A, entitled Environmental Assessment of Airport Development Actions, a "Box Model" (BM) is described for usage in the computation of air pollutant concentrations. According to the report, use of the BM is allowed if a project site is not in an area for which there is a Transportation Control Plan or which has been designated as an Air Quality Maintenance Area.

Within the guidelines noted above, we have been using the BM to help assess the expected impact on air quality of (1) new airports, or (2) expansions of existing airports.

In the discussion of the BM included in Appendix F to the above referenced report, we note that the emission factor values shown in Table III include an assumed wind speed of one meter per second. Do you have any information at hand that lends insight into how the one meter per second velocity was included in the emission factors?

We greatly appreciate whatever information you can provide with respect to the wind velocity aspect of the Box Model.

Sincerely,

Dennis R. Topper

Dennis R. Topper, Capt., USAF
Intern

DRT:tt

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20591

NOV 2 1978

Capt. Dennis R. Topper
USAF Intern
Turner Collie and Braden, Inc.
P.O. Box 13089
Houston, Texas 77019

Dear Capt. Topper:

Thank you for your October 9 letter regarding the use of the Federal Aviation Administration's (FAA) Box Model.

We have been using the Box Model in ways similar to the ones you reported. However, we do not have any information on the "one meter per second" assumption beyond that found on page 1 of Appendix F of the Technical Report FAA-AP-77-1A you cited in your letter. As we understand it, the reason given for the "assumed" (forward-progressive) wind speed of one meter per second is simply to denote a static air condition at the airport, thus denoting a "worst case" or near zero wind speed situation.

We have contacted the Environmental Protection Agency group at Research Triangle Park, North Carolina, which prepared the original Model and inputs, to try to resolve several questions concerning the Box Model and its uses. As further information is developed we will gladly share it with you.

Sincerely,

JOHN R. GOODWIN, Chief
Airports Planning Division, AAP-400
Office of Airports Programs

Turner Collie & Braden Inc.

P.O. Box 13089
Houston, Texas 77019
5757 Woodway
713 780 4100
Telex 77-4185

January 24, 1979

Federal Aviation Administration
INM Bulletin
Office of Environmental Quality
AEQ-110
300 Independence Avenue, S.W.
Washington, D. C. 20591

Gentlemen:

We have been using the FAA's Integrated Noise Model (INM) to predict the composite noise energy generated by 1) operations at new airports and 2) expanded operations at existing airports. We have used both the contour and grid analysis modes with the contour mode being the primary usage.

Occasionally, our clients have asked us if the INM has ever been verified in some manner. Our response has been that "validation is underway" based upon a comment in the January 1978 edition of the INM's Basic User's Guide (Report FAA-EQ-78-01). On page 1-10 you state, "A validation study of the INM is currently in progress."

If the validation study has been completed we are very interested in reviewing not only the final results but also, the methodology behind the verfication process.

Would you please forward us any information you may have about the validation of the INM?

Your cooperation in this matter will be greatly appreciated.

Sincerely,

Dennis R. Topper

Dennis R. Topper, Captain, USAF
Intern

DRT:ds

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20591

February 23, 1979

Captain Dennis R. Topper
Intern, United States Air Force
Turner Collie & Braden, Inc.
P.O. Box 13089
Houston, Texas 77019

Dear Captain Topper:

The Integrated Noise Model (INM) validation study to which you referred to in your letter of January 24 is ongoing.

The purpose of the study is to obtain and analyze empirical noise data from the permanent noise monitoring system of Dulles International and Washington National Airports to determine the accuracy of the INM. The analysis focuses on a comparison between measured noise levels at monitoring microphone locations and computer noise levels at the same locations using actual operations and flight track data as input to the INM.

The initial phase of the project established the proof of concept of the statistical procedures for the data comparisons. The present phase of the project is concerned with the refinement of the definition of the aircraft types being monitored at the two area airports. Preliminary comparison results have been produced in conjunction with the beginning phases of the project. However, no results will be published until statistical confidence is established.

Independent of the agency's validation study, short-term validation studies have been conducted. The enclosed letter between Bolt, Beranek and Newman, Inc., and the Massachusetts Port Authority indicates one such study. Because of the small sample size involved in the analysis, the statistical confidence of the results is limited. A significantly large sample of data is needed to establish high confidence in the results. A large sample of aircraft noise data can be obtained only over a large period of time.

Your interest in the INM is appreciated. If we can be of further help, please advise.

Sincerely,

THOMAS L. CONNOR
Operations Research Analyst
Office of Environment and Energy

Enclosure

50 Moulton Street
Cambridge, Mass. 02138
Telephone (617) 491-1850
Telex No. 92-1470

Bolt Beranek and Newman Inc.

26 December 1978

Ms. Donna Berman
Massachusetts Port Authority
Logan International Airport
East Boston, Mass. 02128

Dear Donna:

We have reviewed the existing noise measurement data collected by Massport during the operational testing of the alternative departure procedures for 22R and feel that no additional measurements need be made for the purpose of validating the Integrated Noise Model (INM). Although this does not preclude the possibility that you may want to carry out additional monitoring in response to community requests, the data collected to date do provide reasonable support for the INM.

Our conclusion is based on examination of the aircraft altitude information taken from the ARTS III radar scope as well as on the peak sound levels measured at each of the monitoring sites. Since our previous work had shown that the noise environment around Logan was dominated by the 727, we concentrated on the noise and performance data for that aircraft. Because of the 727's significance, any error in the INM data base for that aircraft would thus have the greatest influence on the accuracy of cumulative noise exposure calculations made by the INM.

Comparing the recorded altitudes with the altitude profiles in the INM, we found that the INM resulted in an average underprediction of about 150 feet in the slant distance to the aircraft from the measurement position. This in turn would result in an average overprediction of about 0.3 dB for single event noise levels, due solely to differences in altitudes.

We should point out, however, that the profiles in the INM are for the old ATA takeoff procedures. The power cutback under that procedure occurred at 1500 feet. Under the new procedure being flown now, aircraft begin their cutback at 1000 feet and thus tend to be slightly lower in altitude on departure. With the INM modified to account for the new procedures, the underprediction of altitude and resulting overprediction of sound level would thus be slightly greater than we have found here.

We next compared noise levels at those monitoring positions where altitude information was also available. To compare levels, however, the measured peak A-weighted sound levels were converted to Sound Exposure Levels by adding an adjustment to account for duration. This adjustment was necessary since the INM uses Sound Exposure Levels in the calculation of L_{dn}. In this case, we found that the INM resulted in an average underprediction of the measured levels by about 1.3 dB. Although the causes of this difference cannot be isolated, the underprediction could easily be due to variations in thrust settings or in sound propagation between the measurement conditions and modelling conditions.

Finally, when we add together the errors, we note that the model results in a total average underprediction of about 1.0 dB. The actual range of errors over all of the monitoring sites is from an underprediction of 5.4 dB to an overprediction of 3.7 dB. Given the fact that variables such as thrust, speed, and weight were unknown during the measurement program, we consider this to be very reasonable agreement. We would also add that even better correlation should be achieved when the INM is corrected to account for the new ATA procedure.

In summary, we believe the data collected do validate the INM and help to justify its use as a tool in evaluating the 22R departure alternatives, just as the measurements themselves will prove useful in the evaluation.

Very sincerely,

BOLT BERANEK AND NEWMAN INC.

Bob Miller

Robert L. Miller

RLM/cmm

INTERN EXPERIENCE WITH

TURNER COLLIE & BRADEN INC.

VOLUME III

AN INTERNSHIP REPORT

by

Dennis Richard Topper

Submitted to the College of Engineering
of Texas A&M University
in partial fulfillment of the requirement for the degree of

DOCTOR OF ENGINEERING

August 1979

Major Subject: Civil Engineering

INTERN EXPERIENCE WITH

TURNER COLLIE & BRADEN INC.

VOLUME III

An Internship Report

by

Dennis Richard Topper

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August 1979

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APPENDIX D

Job No. 2356-010

INTERIM REPORT
MASTER PLAN FOR SANITARY SEWERAGE
NORTHSIDE SERVICE AREA
CITY OF HOUSTON, TEXAS

May 1979

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INTRODUCTION

In March of 1978 Turner Collie & Braden Inc., hereafter referred to as the "Engineers," entered into a contract with the City of Houston to prepare a Master Plan for Sanitary Sewerage for the Northside Service Area of the city. The Engineers last updated the Master Plan in 1965. Revision at this time is needed to incorporate current and future trends plus recent improvements to the system.

This interim report of progress on the Master Plan is in two parts. Part One describes the methodology behind and summarizes the results of the flow projection, deficiency identification, and a portion of the alternative evaluation efforts associated with the preparation of the Plan. Part Two contains a more detailed presentation of the assumptions, results, and recommendations of the Master Planning efforts through May 1979.

PART ONE: METHODOLOGY BEHIND THE PLAN AND SUMMARY OF FINDINGS

Basically the preparation of the Master Plan for Sanitary Sewerage in the Northside Area has involved the establishment of a reliable data base, and projection of flows to the years 1983, 1990, and 2000. In addition, the Engineers have made a comparison of the forecast sanitary sewage quantities to the respective sewer line capacities within the Northside network in order to identify overloaded segments. The procedure

associated with the development of the Master Plan has been as follows:

a. Establish the boundaries of the system.

b. Determine the network of sewer lines with diameter greater than 12 inches.

c. Divide the network into subareas and minisystems.

d. Project in acres the land uses present in each minisystem for each of 1983, 1990, and 2000.

e. Develop flow factors.

f. Project flows by minisystem and compare to capacity.

g. Evaluate alternatives to relieve overloaded lines.

Each of these steps will be explained in the sections to follow. In order to exp[illegible] the planning effort and allow for a more complete analysis of the system the Engineers developed a computer program to aid in steps "f" and "g" above.

Northside Service Area Boundaries

Exhibit 1 depicts the area encompassed by the Northside Sanitary Sewer System and its major subsystems. The area is the largest in Houston and serves about half a million people. Total acreage is approximately 59,500 acres.

Sewer Line Network

Exhibit 2 shows the existing collection system network of lines 12 inches diameter or greater. The system layout has been derived from past Master Plan Reports, Sewer Surveys, block

sheets, as-built drawings, and field inspections. With the information from these references the Engineers computed the capacities of the sewer lines in the network. This data will be used later in the Plan to identify those line segments already overloaded or projected to be deficient over the time span of the Plan.

Division of the Network into Subareas and Minisystems

In order to facilitate the flow projection and to better highlight forecasted deficiencies the Engineers divided the Northside region into nine subareas - A through I as shown on Exhibit 1. Their approximate boundaries are delineated below.

Subarea A lies in the southeasternmost part of the Northside Service Area. Boundaries to Subarea A include 1) the Houston Ship Channel to the east, 2) Bray's Bayou and the Kansas and Texas railroad tracks to the south and west, and 3) Buffalo Bayou to the north.

Subarea B is located in the south-central portion of the region and contains the downtown area of Houston. The area is bounded on the north by Buffalo Bayou, U. S. Highway 59 to the east, and Interstate Highway 45 to the south and west.

Subarea C lies the farthest west of the subareas. Boundaries for Subarea C include the Hempstead Highway and Interstate 610 to the east, Memorial Park and Interstate 10 to the south, Bunker

Hill and Crestdale roads on the west, and Emnora and Kempwood Streets to the north.

Located in the northwest central area of the region, Subarea D has boundaries as follows: Ella Boulevard, Attridge Street, and T.C. Jester Road to the east, the Missouri, Kansas, and Texas railroad from White Oak Bayou to Hempstead Road to the south, the Hempstead Road to the west, and Lumberdale, Bolin, and Northrup Streets to the north.

Subarea E is in the south central region of the Northside Service Area. The subarea is bounded by West 27th Street to the north, Heights Boulevard to the east, Buffalo Bayou to the south, and White Oak Bayou and Memorial Park to the west.

Subarea F is the largest in the Northside Sanitary Sewer System. Boundaries of the subarea are as follows:

To the North - Manfield Road, Ester Street, West Canino Road, East Canino Road, West Little York Road, Junell Street, DeWalt Street, and Ferguson's Way Street

To the South - Pinemont Street, the North Loop 610, West 35th Street, West 27th Street, the Houston Belt and Terminal Railroad Tracks

To the West - Wheatley Street, Phillips Street, Ella Boulevard, Brinkman Street, Rosslyn Road

To the East - East Hardy Road

Subarea G is centrally located in the Northside Service Area. The North Loop of Interstate Highway 610 forms the north boundary to the subarea. The Missouri Pacific Railroad Tracks are the eastern border. Buffalo Bayou and Interstate 10 constitute the southern boundary, and Heights Boulevard and Studemont are the western boundary.

Subarea H lies in the northeast quadrant of the overall master planning region. Boundaries to the subarea include Little York Road, Sagebrush Street, and Halls Bayou to the north, Hirsch Road, Lockwood Street, Homestead Road, Heatherside Street, and the Eastex Freeway to the east, Hunting Bayou to the south, and East Hardy Road to the west.

Subarea I is the easternmost segment of the study area. The subarea is bounded on the north by Interstate Highway 610 and Hunting Bayou, on the east by Homestead Road, on the south by Quittman Street, and on the west by the Missouri and Pacific Railroad.

Each of the above subareas was further split into minisystems as follows:

Subarea	Number of Minisystems
A	26
B	18
C	63
D	48
E	13
F	97
G	53

Subarea	Number of Minisystems
H	55
I	45
Total	418

Exhibit 3 shows the boundaries for each of the minisystems. The minisystem arrangement provides a means to rapidly focus on the sewer lines in the system that will be overloaded over the time frame of the plan.

Projection in Acres of the Land Uses Expected to Exist in Each Minisystem for Each of 1983, 1990, and 2000

In order to accomplish the above task, ten land-use categories were established as follows:

Code	Land Use
1	Single-Family Residential
2	Multi-Family Residential, Low Density
3	Multi-Family Residential, High Density
4	Commercial, Low Density
5	Commercial, High Density
6	Industrial
6	Institutional
8	Parks
9	Rights-of-way
10	Undeveloped

Next, the acreage by land-use type for each minisystem was determined. The existing land use was based upon aerial photographs and field surveys. A prediction of the land use by category for the year 2000 was made for each minisystem. With the existing and year 2000 acreage quantities available, the trend in land use over the next twenty years could be reasonably approximated, thus allowing for the land-use projections of 1983 and

1990. Census tract data facilitated the 1983, 1990, and 2000 forecasts. Table 1 summarizes the results of the land-use forecast.

Development of Flow Factors

In order to project the flows throughout the Northside Service Area, flow factors (FF) in terms of gallons per acre per day (gpad) are multiplied by the respective acreage values obtained above. Flow measurement surveys and information from previous master plans provided the basis for the FF incorporated into this Master Plan.

The computer program mentioned earlier allowed for rapid analysis of the impact on the system of changes in the FF. This capability was especially important in light of the widely variant nature of flow measured for the different classifications of land use. For example, measured flow quantities for the Commercial High Density category range from 13,600 gpad to 120,000 gpad. Measured flow from the Multi-Family High Density land use has varied from 19,000 gpad to 41,000 gpad. The high speed of the computer expedited the review of flows projected on the basis of more than one set of FF. Table 2 is a summary of the two sets of numbers used. They represent a compromise among the differing values of measured peak, wet-weather flow.

The factors have been adjusted to account for the sewer line rehabilitation proposed in the March 1977 Sewer System Evaluation

TABLE 1 - SUMMARY OF LAND-USE FORECAST
HOUSTON NORTHSIDE SANITARY
SEWERAGE SERVICE AREA (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	27,195	27,208	27,531	27,935
Multi-Family Residential, Low Density(1)	373	368	366	347
Multi-Family Residential, High Density(2)	1,528	2,233	2,882	3,835
Commercial, Low Density(3)	5,506	5,619	5,832	6,096
Commercial, High Density(4)	1,415	1,403	1,393	1,378
Industrial	6,828	7,279	7,508	7,843
Institutional	1,307	1,306	1,312	1,307
Parks	2,204	2,196	2,200	2,196
Rights-of-way	4,687	4,659	4,680	4,656
Undeveloped	8,436	7,208	5,775	3,886

(1)Multi-Family, Low Density typically consists of mobile home parks, duplexes, townhouses, and condominiums.

(2)Multi-Family, High Density typically consists of multi-story apartment complexes.

(3)Commercial, Low Density consists of "strip" shopping centers, neighborhood convenience stores, single business buildings, and small office buildings.

(4)Commercial, High Density consists of high rise office buildings and major shopping centers.

TABLE 2 - SUMMARY OF FLOW FACTORS
(GPAD)

Land-Use Category	First Set 1983	First Set 1990	First Set 2000	Second Set 1983	Second Set 1990	Second Set 2000
Single-Family	3,000	4,000	5,000	6,000	7,000	8,000
Multi-Low	12,000	13,000	14,000	12,000	13,000	14,000
Multi-High	17,000	18,000	19,000	17,000	18,000	19,000
Comm-Low	12,000	13,000	14,000	12,000	13,000	14,000
Comm-High	17,000	18,000	19,000	22,000	23,000	24,000
Industrial	3,000	4,000	5,000	3,000	4,000	5,000
Institutional	3,000	4,000	5,000	3,000	4,000	5,000

Survey prepared by Lockwood, Andrews, and Newnam (LAN). In this regard, LAN's recommended repair work is expected to be completed by 1983 and to alleviate some of the infiltration/inflow (I/I) now experienced in the system. Thus, the FF are assumed to be lower in the earlier time frames of the study (1983 and 1990) and higher, since some I/I could reasonably be expected to return, towards the year 2000.

The first set of FF was developed with minor modifications to the values of previous master plans. With the exception of the I/I adjustment noted above, only the numbers for commercial land use, both high and low density, were altered from the FF used in the 1965 plan.

The second set of FF represent an "upper bound" that is based upon the more recent flow measurement surveys undertaken. These FF are about the highest that could reasonably be justified for the Northside Service Area.

The FF used in the study represent prudent planning criteria; however, neither set of FF can adequately describe the flow situation that will exist in the central downtown area (mini-system B-12) of Subarea B to the year 2000. The nature of the land use with numerous high rise, high density commercial buildings of widely differing flows and a complex sewer network with difficult to define flow patterns dictate special considera-tion for the downtown area. Accordingly, for minisystem B-12 the

Engineers recommend that a detailed survey be made. Downtown should be treated as a separate service area with minisystems and FF of its own in order to better plan for the future.

Projection of Flows by Minisystem and Comparison to Capacity

Using the computer program devised in conjunction with this Master Plan, the Engineers projected the flows throughout the Northside Sanitary Sewer network. For each minisystem the predicted quantities were compared to the individual capacities of the minisystems, thus generating a listing of deficient pipes. Exhibits 4 and 5 show the locations of the pipes with excess sewage for the first and second sets of FF. Tables 3 through 6 summarize the results of the flow projection. In general, the projection indicates that significant relief is required for each subarea in the network.

Evaluation of Alternatives to Relieve Overloaded Lines

The two main alternatives for relief of the overloaded lines in the system include the use of parallel and nonparallel relief lines. The Engineers developed and evaluated the alternative scheme shown in Exhibit 6 by dashed lines. They indicate the non-parallel relief segments proposed to alleviate the excess sewage projected for the major trunk sewers. As of May 1979 the Engineers had determined the minimum size parallel relief lines to relieve overloading in the remaining deficient pipes in the network. These lines were determined using Manning's equation with

TABLE 3 - SUMMARY OF PROJECTED FLOWS (GPD)

Year	Projected Flow w/ First Set Flow Factors	Projected Flow w/Second Set Flow Factors
1983	241,310,960	331,038,352
1990	302,851,660	392,776,760
2000	375,467,160	466,182,903

TABLE 4 - SUMMARY OF DEFICIENT PIPE SEGMENTS
1983

Subarea	Number of Deficient Pipes: Total Minisystems in Subarea	Number of Deficient Pipes: 1st Flow Factors	Number of Deficient Pipes: 2nd Flow Factors	Percent of Total Number of Pipes in Subarea: 1st Flow Factors	Percent of Total Number of Pipes in Subarea: 2nd Flow Factors
A	26	10	12	38	46
B	18	1	1	6	6
C	63	18	26	29	41
D	48	18	25	38	52
E	13	8	10	62	77
F	97	34	54	56	56
G	53	22	28	53	53
H	55	5	11	9	20
I	45	7	13	16	29
Totals	418	123 (1)	180 (2)		

(1) Equals 29% of total number of pipes.

(2) Equals 43% of total number of pipes.

TABLE 5 - SUMMARY OF DEFICIENT PIPE SEGMENTS
1990

	Number of Deficient Pipes			Percent of Total Number of Pipes in Subarea	
Subarea	Total Minisystems in Subarea	1st Flow Factors	2nd Flow Factors	1st Flow Factors	2nd Flow Factors
A	26	10	15	38	58
B	18	2	4	6	22
C	63	25	36	40	57
D	48	24	29	50	60
E	13	10	10	77	77
F	97	45	63	46	65
G	53	28	33	53	62
H	55	5	17	9	31
I	45	9	15	20	33
Totals	418	158(1)	222(2)		

(1)Equals 38% of total number of pipes

(2)Equals 53% of total number of pipes.

TABLE 6 - SUMMARY OF DEFICIENT PIPE SEGMENTS
2000

	Number of Deficient Pipes			Percent of Total Number of Pipes in Subarea	
Subarea	Total Minisystems in Subarea	1st Flow Factors	2nd Flow Factors	1st Flow Factors	2nd Flow Factors
A	26	12	15	46	58
B	18	3	5	17	28
C	63	30	41	48	65
D	48	27	38	56	79
E	13	10	11	77	85
F	97	61	74	63	76
G	53	29	34	55	64
H	55	16	27	29	49
I	45	14	17	31	38
Totals		202[1]	262[2]		

[1]Equals 48% of total number of pipes.

[2]Equals 63% of total number of pipes.

roughness, n, equal to .013 and slope equal to the standard grade specified by the City of Houston's specifications. Sizes of both parallel and nonparallel relief lines to accommodate the projected flow to the year 2000 are shown in Exhibit 6. The technical feasibility of the combined relief scheme has not yet been determined. Although the recommended line sizes should be adequate to carry the forecasted quantity of sewage, the technical feasibility of such an extensive relief network is highly questionable. Some of the system will have to remain charged during periods of peak flow.

PART TWO: DETAILED PRESENTATION OF RESULTS

General

In the subsections to follow each subarea is addressed separately to include 1) a tabulation in acres of existing and projected land use, 2) a listing of pipe segments projected to be inadequate to handle forecasted flow for the years 1983, 1990, and 2000, 3) initial parallel relief recommendations, and 4) any unusual assumptions that may have been made for the particular subarea.

Subarea A

Table 7 summarizes the land-use forecast for Subarea A. In general, the subarea will have a trend towards decreased single family residences with increased high density multi-family quarters. A slight diminishing of low density commercial activity

TABLE 7 - LAND USE BY CATEGORY SUBAREA A
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	1,436	1,322	1,222	1,122
Multi-Family Residential, Low Density	2	2	2	2
Multi-Family Residential, High Density	22	113	181	302
Commercial, Low Density	313	338	328	296
Commercial, High Density	0	0	0	0
Industrial	1,041	1,063	1,083	1,103
Institutional	29	29	29	29
Parks	97	89	93	89
Rights-of-way	407	407	407	407
Undeveloped	37	21	39	34

will occur with some increase of industrial acreage. Based on the flow projection of Part One, Subarea A will have between 46 and 58 percent of its pipes overloaded by the year 2000. Table 8 is a listing of the deficient pipes in the subarea.

Subarea B

Table 9 contains the land-use forecast for this subarea which has a primary trend towards fewer single-family residences and more multi-family high density facilities. The remainder of the land use remains fairly stable. The listing of Deficient Pipe Segments, Table 10, is somewhat lacking in that the central downtown area will require a closer evaluation as noted in Part One of this report. Except for the downtown minisystem, the majority of the sewer lines in Subarea B are expected to be adequate over the time period of this Master Plan.

Subarea C

The land-use projection for Subarea C is Table 11. In general, the land use for each category is very stable with the major trends being conversion from undeveloped land to the single-family and multi-family high density residential and industrial land uses. The number of sewer lines expected to be overloaded within this minisystem approaches 65 percent. This high number has necessitated the nonparallel relief scheme outlined in Part One to alleviate the overloading of the major trunk sewer designated

TABLE 8 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA A

1983		1990		2000		
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
A4	2,086,720	A4	2,599,240	A4	3,133,090	21
A5	415,340	A5	762,080	A5	1,119,630	15
A12	1,926,120	A12	2,315,590	A2	241,910	21
A16	731,880	A16	957,350	A12	2,703,160	21
A18	266,640	A18	355,520	A16	1,180,920	15
A20	1,118,950	A20	1,565,280	A18	444,400	27
A21	760,180	A21	1,120,970	A19	3,007,020	21
A24	2,174,610	A24	3,286,830	A20	2,042,940	18
A25	1,019,740	A25	1,873,630	A21	1,496,730	15
A26	809,990	A26	1,389,160	A24	4,602,920	27
A15	240,700	A2	80,290	A25	2,927,500	21
A17	421,440	A11	94,980	A26	2,092,300	18
		A15	606,590	A11	732,570	12
		A17	723,410	A15	970,580	12
		A19	551,760	A17	1,023,480	12

TABLE 9 - LAND USE BY CATEGORY SUBAREA B
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	575	554	477	358
Multi-Family Residential, Low Density	6	6	6	6
Multi-Family Residential, High Density	92	152	206	276
Commercial, Low Density	536	501	540	603
Commercial, High Density	688	688	688	688
Industrial	133	133	133	133
Institutional	101	104	95	97
Parks	219	219	219	219
Rights-of-way	195	195	195	195
Undeveloped	69	62	55	39

TABLE 10 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA B

1983		1990		2000		Minimum Parallel
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Relief Size (In.) - Yr. 2000
B12	1,714,290	B10	419,310	B9	113,180	15
		B12	2,680,590	B10	1,259,770	15
		B1	49,010	B12	3,998,230	24
		B11	56,120	B11	403,730	12
				B1	378,820	12

TABLE 11 - LAND USE BY CATEGORY SUBAREA C
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	3,251	3,320	3,420	3,604
Multi-Family Residential, Low Density	31	31	31	31
Multi-Family Residential, High Density	553	570	592	629
Commercial, Low Density	674	700	716	742
Commercial, High Density	127	127	127	127
Industrial	676	715	735	826
Institutional	247	247	247	247
Parks	646	646	646	646
Rights-of-way	400	400	400	400
Undeveloped	773	622	464	126

"N1" and running the length of the subarea. The complete listing of deficient sewer segments is given in Table 12.

Subarea D

Land use (Table 13) within this subarea shows minor fluctuation. The categories dealing with high density multi-family residences, low density commerce, and industry evidence the greatest increases in acreage with land taken from the undeveloped property in the subarea. The percentage of deficient pipes in Subarea D ranges from 56 to 79 percent. The relief scheme of Part One will alleviate the majority of the excess flow in the subarea.

Subarea E

The only significant land-use trend in this subarea is the conversion of undeveloped land to high density multi-family apartments. The subarea has the highest percentage of overloaded lines in the entire Northside Service Area. This condition results in part from the accumulation of flows which must pass through Subarea E from C and D along the major trunk sewer running through minisystem E4 and E6. Nonparallel relief as depicted in Exhibit 6 will remedy the excess flow of E4 and E6. In addition, eight other minisystems in the subarea are projected to be overloaded by 2000. The minimum size parallel relief lines for these minisystems are included in the listing of Deficient Pipe Segments for Subarea E (Table 16).

TABLE 12 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA C

1983 Mini-system	1983 Deficiency (gpd)	1990 Mini-system	1990 Deficiency (gpd)	2000 Mini-system	2000 Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
C15	624,640	C15	845,240	C15	1,091,210	12
C41	639,200	C41	1,012,830	C41	1,445,640	15
C16	950,380	C16	1,311,150	C16	1,697,290	18
C4	1,525,420	C4	2,104,830	C3	868,900	12
C19	722,310	C43	4,707,500	C4	2,751,540	21
C22	718,580	C45	5,298,370	C43	6,868,080	30
C8	616,880	C38	5,878,830	C45	7,640,720	36
C11	1,454,210	C47	262,370	C38	8,440,870	36
C10	760,300	C6	361,120	C47	791,360	12
C24	2,092,670	C19	851,890	C37	624,800	12
C23	2,267,310	C22	791,080	C6	552,100	12
C26	455,550	C8	711,180	C12	495,510	12
C33	11,451,090	C11	1,321,510	C19	981,450	12
C9	1,926,860	C10	848,600	C22	863,580	12
C28	13,757,590	C24	2,061,450	C8	805,480	12
C30	15,196,090	C23	2,335,880	C11	1,491,150	15
C52	24,863,630	C26	625,940	C10	936,900	12
C34	2,823,480	C33	15,004,260	C24	2,332,570	18
C3	368,740	C9	2,230,880	C23	2,706,790	21
C43	2,738,790	C57	750,110	C25	124,450	12
C45	3,180,210	C53	64,460	C26	796,[illegible]30	12
C38	3,515,720	C28	18,171,120	C33	19,390,[illegible]	48
C6	188,160	C30	19,866,320	C9	2,534,[illegible]0	21
C12	180,850	C52	31,002,540	C57	1,281,[illegible]30	15
C57	385,550	C34	6,158,800	C53	164,310	12
C29	161,570	C2	55,950	C28	23,267,200	48

1990 Mini system	1990 Deficiency (gpd)	2000 Mini-system	2000 Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
C17	58,440	C29	529,930	12
C1	39,630	C30	25,463,050	48
C3	618,440	C52	38,616,490	72
C20	2,700	C34	10,041,320	36
C12	339,100	C2	158,370	12
C25	37,660	C17	1,290,390	15
C27	123,920	C1	148,130	12
C32	111,020	C18	364,190	12
C29	343,900	C46	58,388	12
		C20	812,720	12
		C35	81,020	12
		C27	648,330	12
		C48	239,480	12
		C32	272,340	12
		C56	18,990	12

TABLE 13 - LAND USE BY CATEGORY SUBAREA D
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	3,316	3,360	3,424	3,543
Multi-Family Residential, Low Density	88	84	86	82
Multi-Family Residential, High Density	269	320	396	492
Commercial, Low Density	601	622	687	735
Commercial, High Density	274	262	252	237
Industrial	864	878	903	949
institutional	191	191	191	191
Parks	277	277	277	277
Rights-of-way	476	476	476	476
Undeveloped	1,086	972	750	460

TABLE 14 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA D

1983		1990		2000		
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
D1	790,910	D1	1,033,600	D1	1,276,290	15
D15	334,420	D18	301,540	D18	540,520	12
D2	2,449,390	D15	536,360	D15	804,600	12
D25	952,910	D2	3,175,770	D2	4,056,970	24
D7	1,177,500	D25	1,327,000	D25	1,701,090	18
D9	3,552,220	D7	1,527,150	D7	1,876,800	21
D13	793,290	D9	4,111,620	D9	4,671,020	27
D28	146,630	D13	1,662,260	D19	611,160	12
D30	277,540	D27	8,806,390	D20	532,620	12
D31	858,020	D28	237,470	D13	3,297,010	24
D33	13,098,530	D30	502,810	D27	13,659,240	42
D26	570,620	D31	1,483,920	D28	328,310	12
D35	388,610	D32	1,379,830	D30	888,820	12
D40	700,200	D33	18,152,530	D31	2,348,900	18
D37	3,871,330	D34	9,802,160	D32	1,703,090	18
D45	15,034,280	D38	12,471,130	D33	23,830,460	48
D47	15,286,260	D26	890,440	D34	15,812,150	42
D46	10,578,590	D35	747,800	D38	18,897,300	48
D18	128,860	D40	1,289,410	D26	1,420,880	15
D27	5,323,390	D37	5,201,540	D35	1,317,000	15
D32	210,010	D45	22,697,480	D40	2,157,530	18
D34	4,339,670	D47	21,615,980	D37	6,766,930	30
D43	122,290	D46	17,248,980	D45	31,201,820	54
D39	6,536,340	D39	12,364,530	D47	29,439,830	54
D38	6,634,740	D16	115,350	D48	181,720	12
		D22	1,006	D46	25,496,050	48
		D20	6,760	D39	18,782,500	42
		D43	320,670	D16	494,550	12
		D44	118,820	D5	327,890	12

TABLE 14 (Cont'd)

	1983		1990		2000	Minimum Parallel
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Relief Size (In.) - Yr. 2000
				D4	227,530	12
				D3	108,610	12
				D12	38,850	12
				D11	1,066,860	12
				D8	329,220	12
				D22	395,800	12
				D14	56,140	12
				D43	521,250	12
				D44	412,670	12

TABLE 15 - LAND USE BY CATEGORY SUBAREA E
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	1,369	1,351	1,306	1,252
Multi-Family Residential, Low Density	0	0	0	0
Multi-Family Residential, High Density	48	106	181	287
Commercial, Low Density	488	466	478	488
Commercial, High Density	42	42	42	42
Industrial	140	140	144	147
Institutional	48	48	48	48
Parks	134	134	134	134
Rights-of-way	98	98	98	98
Undeveloped	720	702	656	591

TABLE 16 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA E

1983		1990		2000		Minimum Parallel Relief Size (In.) - Yr. 2000
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	
E1	1,619,000	E1	970,470	E1	2,381,100	21
E2	3,261,410	E2	2,290,180	E2	4,363,170	27
E5	5,149,350	E5	4,002,310	E5	6,427,940	30
E6	80,468,670	E6	62,792,810	E6	101,158,830	108
E4	62,502,130	E4	47,915,870	E4	79,506,210	108
E10	742,310	E10	556,860	E10	927,760	12
E11	2,005,490	E11	1,501,980	E11	2,548,460	21
E13	3,694,230	E13	2,739,320	E13	4,748,770	27
E12	377,540	E12	227,140	E12	527,940	12
E8	592,870	E8	256,080	E8	1,034,820	12
				E3	80,530	12

Subarea F

The largest subarea in the Northside Sanitary Sewerage Service Area displays the land use of Table 17. Approximately seventy percent of Subarea F's lines are forecasted to be inadequate by the year 2000. Part One's relief network will only carry a portion of the excess flow. Parallel relief lines capable of handling the remainder of the sewage are listed in Table 18.

Subarea G

Subarea G contains the most complex flow pattern in the entire Northside Sanitary Sewerage Service Area. The accumulated flow from Subareas B, C, D, E, and F is conveyed through "G" to the sewage treatment plant. The result is a region with approximately 60 percent of its sanitary lines overloaded. The flow from C, D, and E is split at minisystem G32 (see Exhibit 3). Approximately 90 percent of this split flow travels to Subarea I via minisystem I19. The remainder enters Subarea I via minisystems I45 and I36. The relief alternative of Part One alleviates the excess flow through much of Subarea G. However, additional parallel relief will likely be required.

Subarea H

"H" displays a trend to residential development - both single- and multi-family. In addition, industry will show some expansion to the year 2000. In general, the subarea is capable of handling the flow projected over the time span of this Master Plan. Only

TABLE 17 - LAND USE BY CATEGORY SUBAREA F NORTHSIDE HOUSTON SANITARY SEWERAGE MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	6,840	7,121	7,432	7,929
Multi-Family Residential, Low Density	110	110	110	110
Multi-Family Residential, High Density	302	388	447	521
Commercial, Low Density	1,236	1,349	1,358	1,433
Commercial, High Density	128	128	128	128
Industrial	309	313	315	319
Institutional	330	330	330	330
Parks	155	155	155	155
Rights-of-way	514	514	514	514
Undeveloped	2,204	1,720	1,339	689

TABLE 18 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA F

1983		1990		2000		Minimum Parallel Relief Size (In.) - Yr. 2000
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	
F1	171,840	F22	1,916,790	F1	597,200	12
F2	371,700	F33	3,289,830	F2	863,680	12
F6	260,760	F35	4,890,430	F6	927,060	12
F22	1,136,920	F51	6,429,960	F22	2,966,890	21
F33	2,094,310	F48	2,568,380	F33	4,926,840	27
F23	567,060	F49	1,048,830	F4	8,330	-
F34	983,310	F65	951,580	F8	331,300	24
F35	2,575,050	F63	2,436,860	F23	1,522,380	15
F44	878,760	F66	745,450	F34	4,913,110	27
F51	3,228,480	F62	3,980,220	F47	1,149,530	15
F48	1,782,260	F61	15,263,080	F46	1,316,690	15
F49	111,860	F69	15,933,190	F35	8,525,220	36
F65	684,590	F12	873,280	F44	7,815,670	36
F63	1,124,030	F25	2,141,560	F37	230,230	12
F66	569,120	F26	472,460	F51	11,207,490	36
F62	2,370,100	F32	2,708,080	F48	4,189,380	27
F61	10,288,800	F38	4,148,880	F49	2,891,580	21
F69	10,757,670	F43	2,472,900	F65	1,218,570	15
F12	527,620	F59	6,163,100	F63	4,655,470	27
F25	1,293,770	F70	26,024,320	F66	921,780	12
F26	347,680	F75	27,396,770	F62	6,496,200	30
F32	1,643,010	F76	793,230	F61	22,726,610	48
F38	2,886,340	F74	30,816,330	F60	243,910	12
F43	486,490	F55	866,190	F69	23,593,880	48
F59	3,856,690	F56	1,157,830	F12	1,270,750	15
F70	18,481,940	F72	1,426,580	F21	1,119,520	15
F28	58,280	F73	2,309,560	F25	3,245,630	24
F41	525,030	F85	3,153,810	F26	601,660	12
F42	237,180	F79	1,626,700	F32	4,036,590	24
F75	17,589,360	F91	1,330,630	F38	5,674,860	27

TABLE 18 (Cont'd)

1983 Mini-system	1983 Deficiency (gpd)	1990 Mini-system	1990 Deficiency (gpd)	2000 Mini-system	2000 Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
F76	714,720	F93	1,583,300	F19	224,260	12
F74	20,689,090	F96	1,151,040	F27	450,080	12
F55	490,750	F95	1,480,850	F30	64,600	12
F56	711,610	F80	7,592,870	F40	764,790	12
F72	836,040	F88	1,545,670	F43	4,910,830	27
F73	1,589,870	F97	1,274,550	F53	259,440	12
F85	2,232,630	F82	6,127,240	F59	8,967,710	36
F79	1,397,430	F90	7,660,870	F70	36,573,950	60
F91	1,182,310	F68	1,432,050	F17	198,100	12
F93	1,146,720	F77	1,909,750	F15	511,810	12
F96	974,330	F83	550,180	F14	137,020	12
F95	989,'30	F89	7,662,690	F28	344,280	12
F80	6,444,180	F84	5,026,900	F41	1,290,590	15
F88	1,325,490	F87	48,002,730	F42	1,259,500	15
F97	871,420	F67	762,580	F54	479,010	12
F82	4,799,530	F1	386,010	F58	1,343,480	15
F90	6,314,070	F2	619,180	F71	138,960	15
F68	1,183,760	F6	595,710	F75	40,544,120	72
F77	1,390,240	F23	1,010,040	F76	871,740	12
F83	484,360	F34	2,685,140	F74	44,259,890	72
F89	5,679,930	F47	340	F55	1,093,870	12
F84	2,988,120	F44	3,551,730	F56	1,459,830	15
F87	34,750,900	F60	115,780	F72	1,857,000	18
F67	645,440	F21	449,860	F73	2,896,960	21
		F27	28,590	F85	3,942,700	24
		F40	25,710	F79	1,855,970	18
		F53	120,510	F91	1,478,950	15
		F17	62,020	F92	218,550	12
		F15	163,430	F93	2,079,640	15
		F28	201,280	F96	1,387,560	15
		F41	896,700	F95	2,032,080	18

TABLE 18 (Cont'd)

1983		1990		2000		Minimum Parallel Relief Size (In.) -
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Yr. 2000
		F42	688,700	F94	45,770	12
		F92	45,280	F80	8,802,690	36
				F88	1,767,170	18
				F97	1,679,000	15
				F82	7,516,080	30
				F90	9,068,800	36
				F68	1,741,200	18
				F77	2,471,980	21
				F83	616,000	12
				F89	9,749,300	36
				F84	7,169,530	30
				F87	64,547,370	90
				F67	887,660	12

TABLE 19 - LAND USE BY CATEGORY SUBAREA G
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	4,929	4,558	4,489	4,186
Multi-Family Residential, Low Density	36	36	36	36
Multi-Family Residential, High Density	116	335	505	738
Commercial, Low Density	696	737	742	787
Commercial, High Density	12	12	12	12
Industrial	936	1,188	1,235	1,288
Institutional	153	153	153	153
Parks	457	457	457	457
Rights-of-way	958	943	948	949
Undeveloped	497	371	213	184

TABLE 20 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA G

1983		1990		2000		Minimum Parallel
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Relief Size (In.) - Yr. 2000
G2	1,033,980	G2	1,216,900	G1	165,780	12
G5	1,739,230	G5	2,504,990	G2	1,394,780	15
G9	1,124,080	G11	90,649,900	G5	3,312,620	21
G11	75,587,380	G12	3,774,530	G9	1,759,050	15
G10	919,130	G10	1,567,600	G11	109,519,650	108
G12	2,851,950	G27	84,386,340	G10	2,275,440	18
G27	65,213,240	G24	51,080,950	G13	286,330	21
G29	315,270	G13	192,340	G12	4,749,390	27
G25	155,780	G14	415,040	G27	106,708,900	108
G24	35,304,790	G15	1,211,720	G29	968,520	12
G31	6,180,945	G16	1,085,670	G25	534,130	12
G32	94,102,635	G18	155,255,000	G25A	310,480	12
F23	139,681,396	G17	154,586,262	G24	70,630,330	108
G38	152,880	G19	-	G31	9,265,214	36
G37	597,050	G20	-	G32	133,414,556	120
G40	242,110	G29	646,240	G23	215,169,536	144
G47	513,080	G47	809,340	G21	671,890	12
G51	1,592,340	G51	2,174,100	G38	197,220	12
G30	1,040,890	G30	1,246,860	G37	2,630,340	21
G44	178,950	G43	11,103,539	G40	2,695,490	21
G43	7,433,475	G41	22,661,960	G42	2,915,024	21
G41	19,611,630	G31	7,576,429	G47	1,106,600	15
G13	10,670	G32	112,308,951	G48	10,440	-
G14	82,260	G23	174,075,372	G51	2,800,220	21
G15	648,750	G21	279,810	G30	1,452,830	15
G16	163,380	G38	174,820	G44	937,990	12
G17	119,034,346	G42	1,114,959	G43	15,319,284	42
G18	119,594,596	G9	1,436,340	G41	26,060,020	48
G19	-	G1	42,880	G13	438,560	12
G20	-	G3	98,100	G14	845,650	36

TABLE 20 (Cont'd)

1983		1990		2000		
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
G42	-	G25	336,910	G15	1,851,750	18
		G254	82,110	G16	2,010,140	18
		G37	1,567,000	G17	196,892,796	132
		G40	1,388,920	G18	197,693,936	132
		G44	534,340	G19	-	-
				G20	-	-

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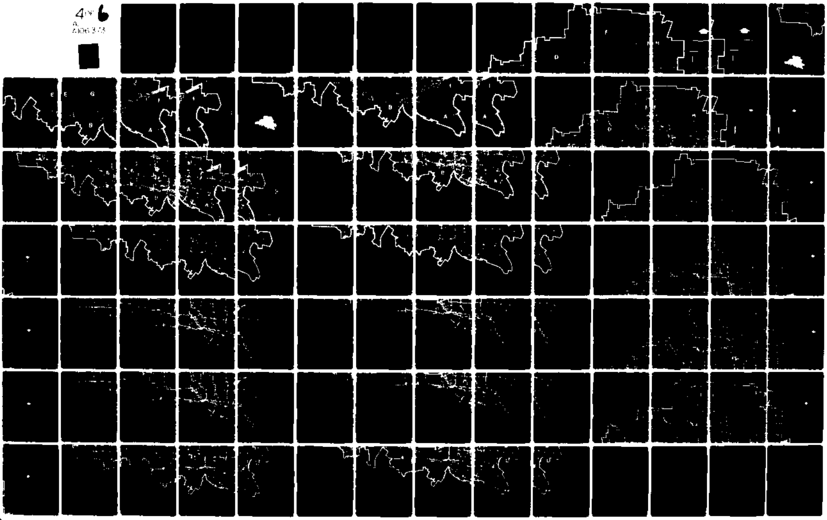


TABLE 21 - LAND USE BY CATEGORY SUBAREA H
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	3,501	3,691	3,903	4,168
Multi-Family Residential, Low Density	72	71	67	52
Multi-Family Residential, High Density	67	120	167	273
Commercial, Low Density	661	598	668	681
Commercial, High Density	73	73	73	73
Industrial	177	192	208	234
Institutional	133	133	133	133
Parks	140	140	140	140
Rights-of-way	832	820	824	818
Undeveloped	1,926	1,744	1,399	1,010

TABLE 22 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA H

1983		1990		2000		
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
H4	155,840	H4	248,330	H1	42,120	12
H5	270,560	H5	467,920	H4	362,820	12
H16	346,600	H16	530,600	H5	665,280	12
H24	44,960	H15	208,490	H19	193,390	12
H34	1,018,330	H24	319,290	H18	348,830	12
H28	121,860	H25	373,990	H16	759,920	12
H26	723,700	H34	1,561,740	H15	3,195,440	21
H30	332,320	H33	754,550	H24	616,130	12
H41	891,980	H39	653,330	H25	802,380	12
H31	96,780	H40	218,950	H32	972,210	12
H42	712,140	H28	282,180	H37	127,360	12
		H26	884,060	H34	2,131,000	18
		H30	493,050	H83	1,648,940	15
		H41	1,265,410	H39	6,017,430	30
		H31	221,660	H40	814,020	12
		H42	2,665,760	H23	119,430	12
		H46	289,530	H28	535,330	12
				H26	1,011,100	12
				H30	711,460	12
				H41	2,119,280	18
				H31	788,440	12
				H42	5,705,000	27
				H44	212,940	12
				H45	41,300	12
				H46	790,000	12
				H52	78,150	12
				H54	2,180,060	18

TABLE 23 - LAND USE BY CATEGORY SUBAREA I
NORTHSIDE HOUSTON SANITARY SEWERAGE
MASTER PLAN (ACRES)

Land-Use Code	Existing	1983	1990	2000
Single-Family Residential	1,978	1,931	1,858	1,773
Multi-Family Residential, Low Density	28	28	28	28
Multi-Family Residential, High Density	59	129	207	317
Commercial, Low Density	301	308	315	331
Commercial, High Density	71	71	71	71
Industrial	2,552	2,657	2,752	2,844
Institutional	75	71	86	79
Parks	79	79	79	79
Rights-of-way	807	806	818	799
Undeveloped	1,124	994	860	753

about 35 percent of the sewer lines exceed capacity and of these segments the majority are not severely overloaded.

Subarea I

The land-use trend in Subarea I shows very little change with some growth of industry and a decline in single family residences. Like Subarea H, Subarea I has few deficient pipe segments (Table 24); however, unlike "H," the inadequate sewer lines in I are for the most part extremely overloaded. This situation arises because all of the accumulated flow from the service area must pass through "I" in order to reach the sewage treatment plant.

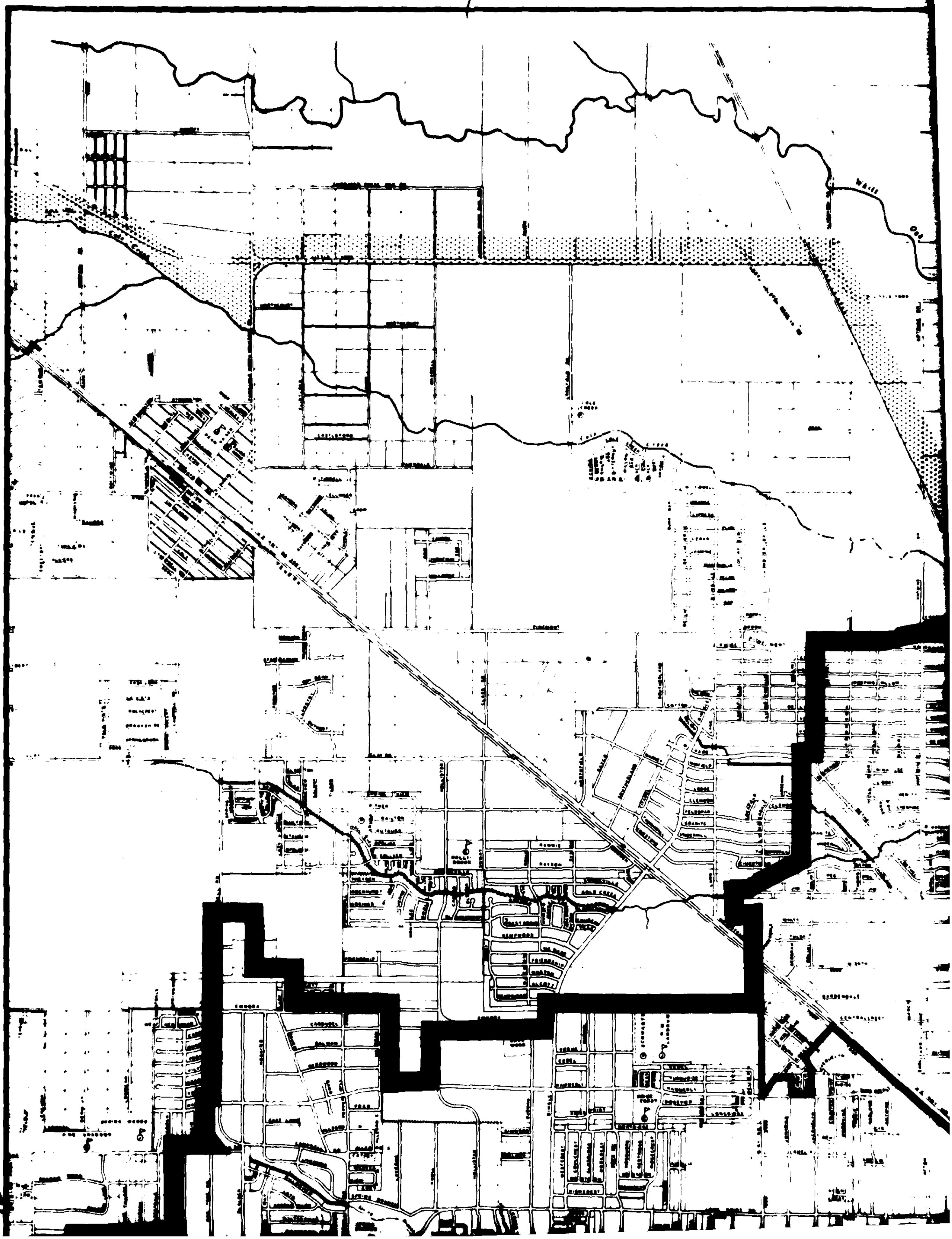
Conclusion

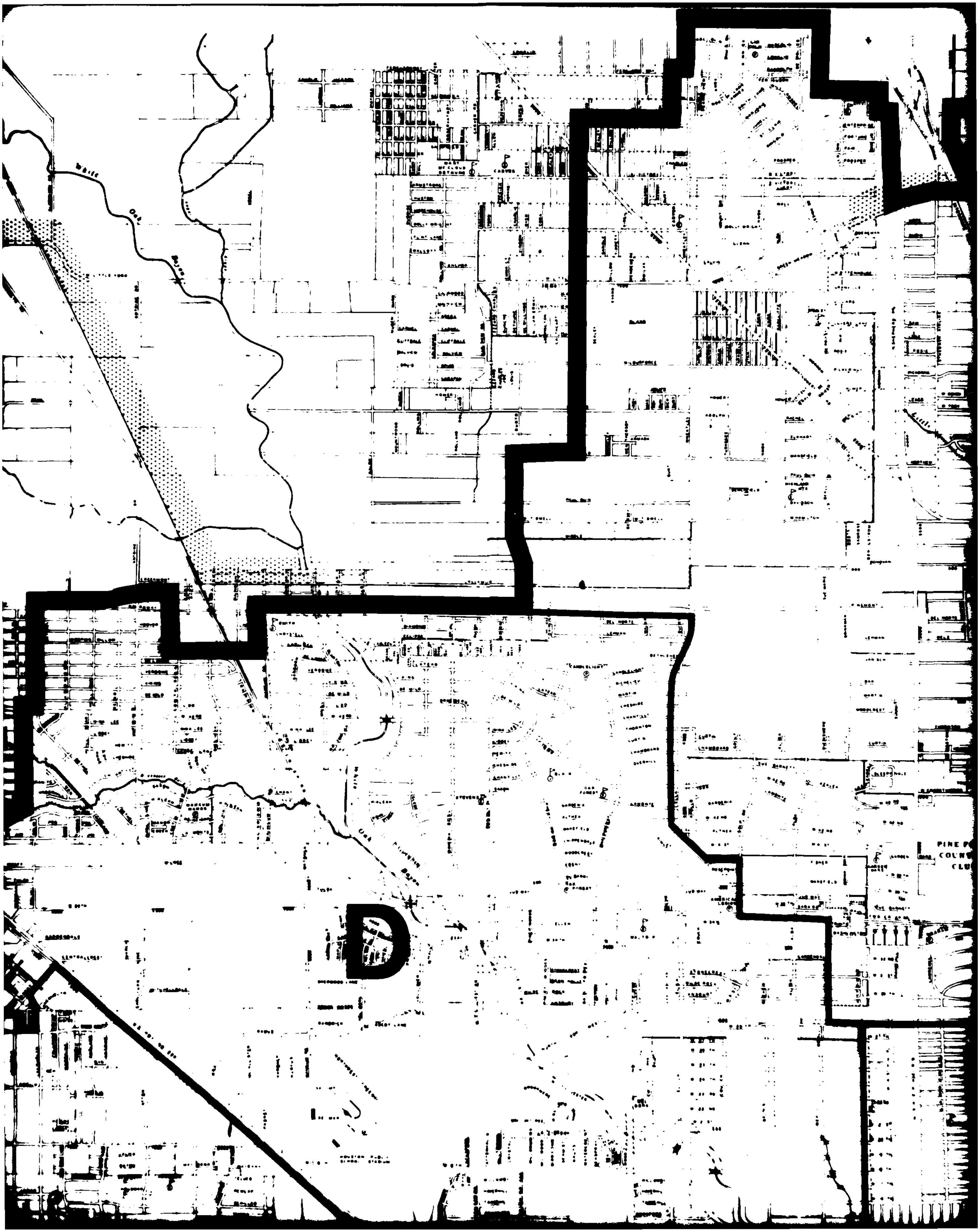
The Northside Sanitary Sewerage Service Area is now and will be even more overloaded in the future. Technical feasibility of identified alternatives to relieve excess flow must be accomplished at the earliest possible date to allow for an orderly approach to relief over the next two decades. A separate study of the downtown area should be authorized as soon as possible also to permit a more accurate Master Plan for that part of the Northside Service Area.

TABLE 24 - LISTING OF DEFICIENT MINISYSTEMS
SUBAREA I

1983		1990		2000		
Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Mini-system	Deficiency (gpd)	Minimum Parallel Relief Size (In.) - Yr. 2000
I10	7,232,000	I11	781,600	I10	17,160,900	42
I11	8,636,700	I16	4,556,290	I11	18,790,110	42
I12	151,570	I17	6,203,080	I12	580,740	12
I16	13,220,670	I41	8,807,070	I16	24,456,020	48
I17	15,239,090	I38	8,613,330	I17	26,902,380	48
I41	11,189,680	I42	2,445,730	I21	80,250	12
I38	11,347,500	I34	36,600	I19	350,040	12
I42	5,466,620	I33	752,370	I41	13,863,070	42
I34	207,970	I36	9,476,085	I38	14,372,450	42
I33	1,173,490	I45	11,035,340	I42	8,784,400	36
I36	14,330,920	I44	12,112,060	I34	438,780	12
I45	14,156,220	I43	15,237,080	I33	1,718,540	18
I44	15,477,070	I32	155,228,860	I36	20,022,774	48
I43	19,170,710			I45	17,624,830	42
I32	202,566,580			I44	19,204,110	48
				I43	23,487,700	48
				I32	259,975,868	144

EXHIBITS

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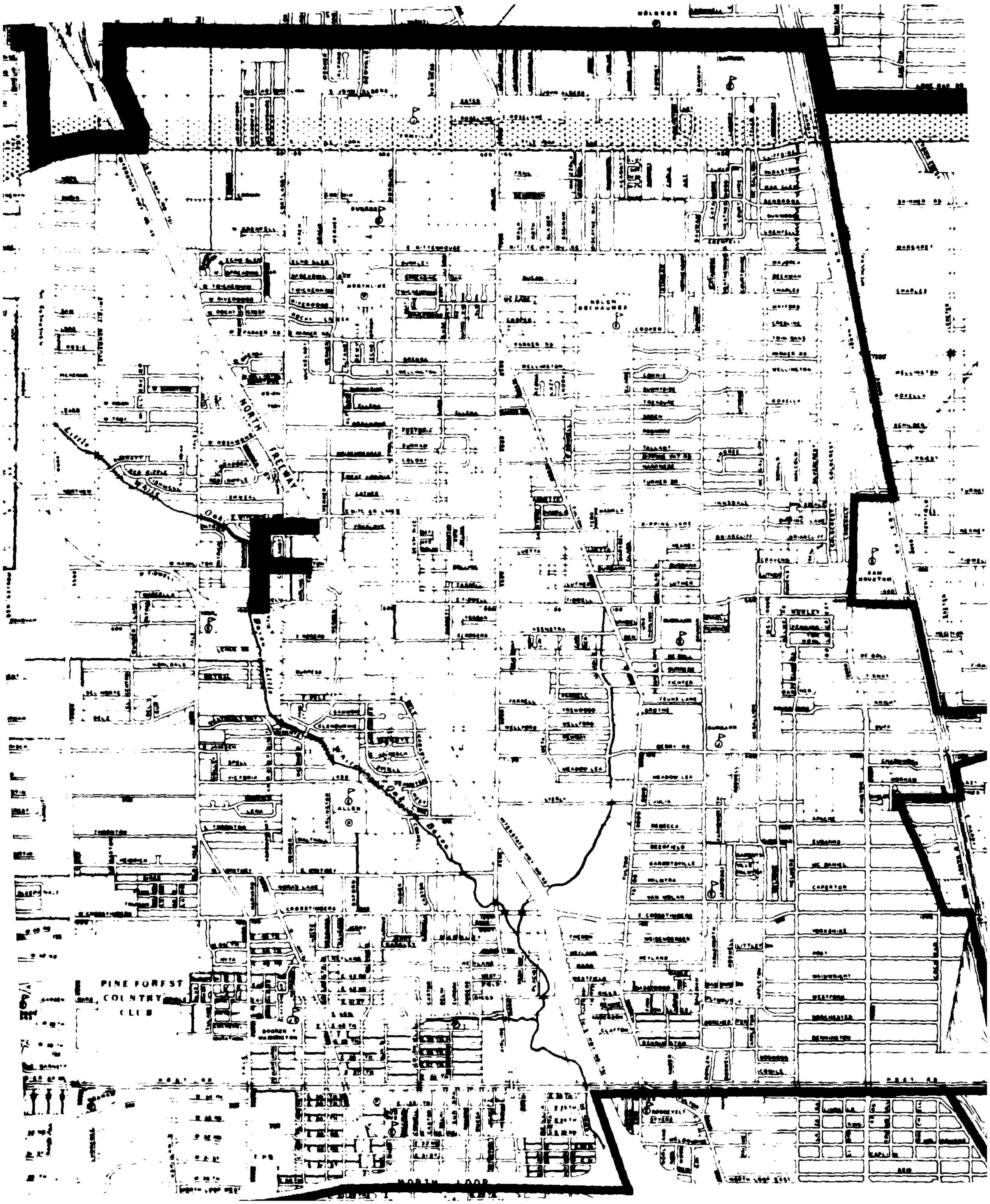
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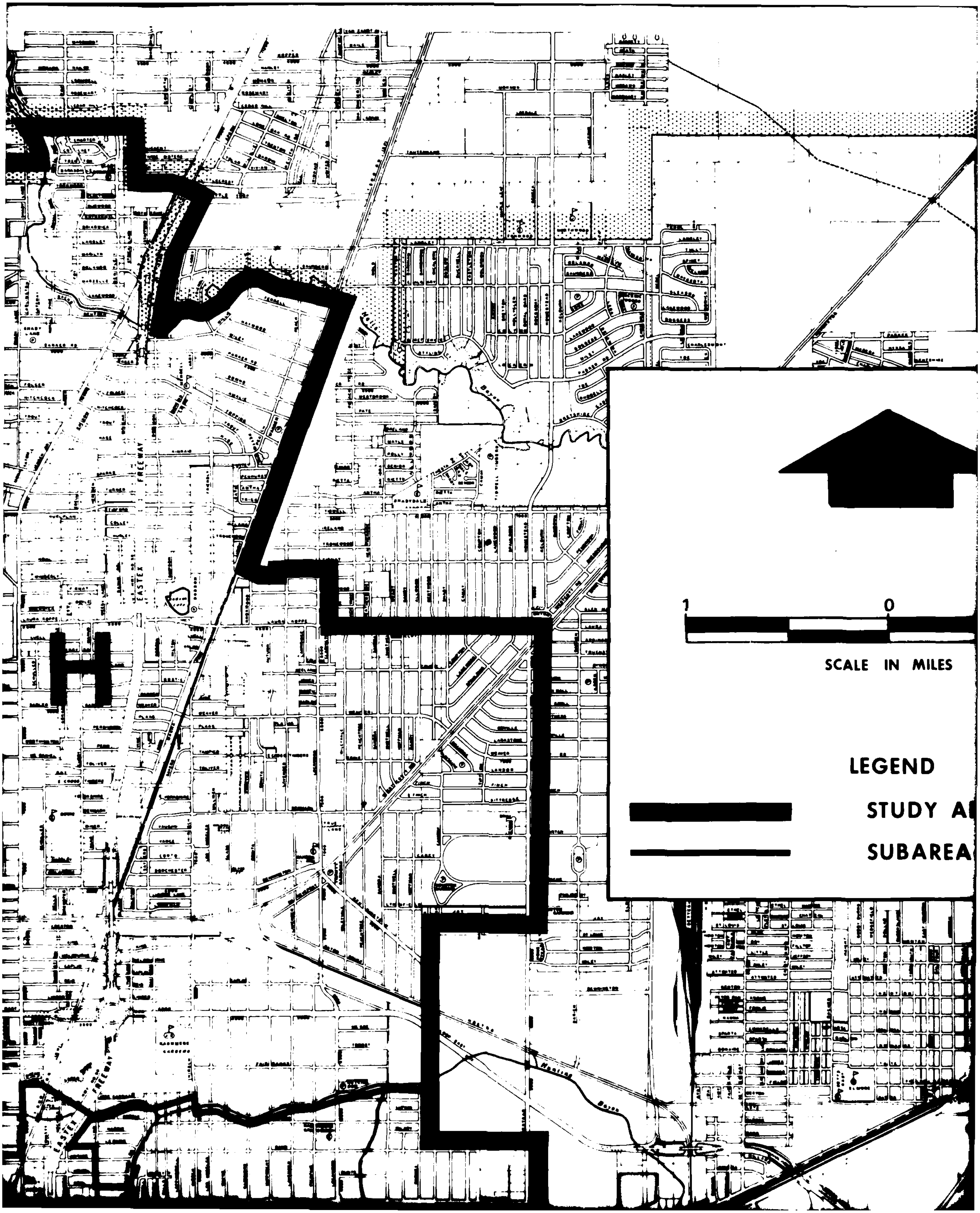
PINE FOREST
COUNTRY
CLUB
NORTH LOOP



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STUDY A
SUBAREA
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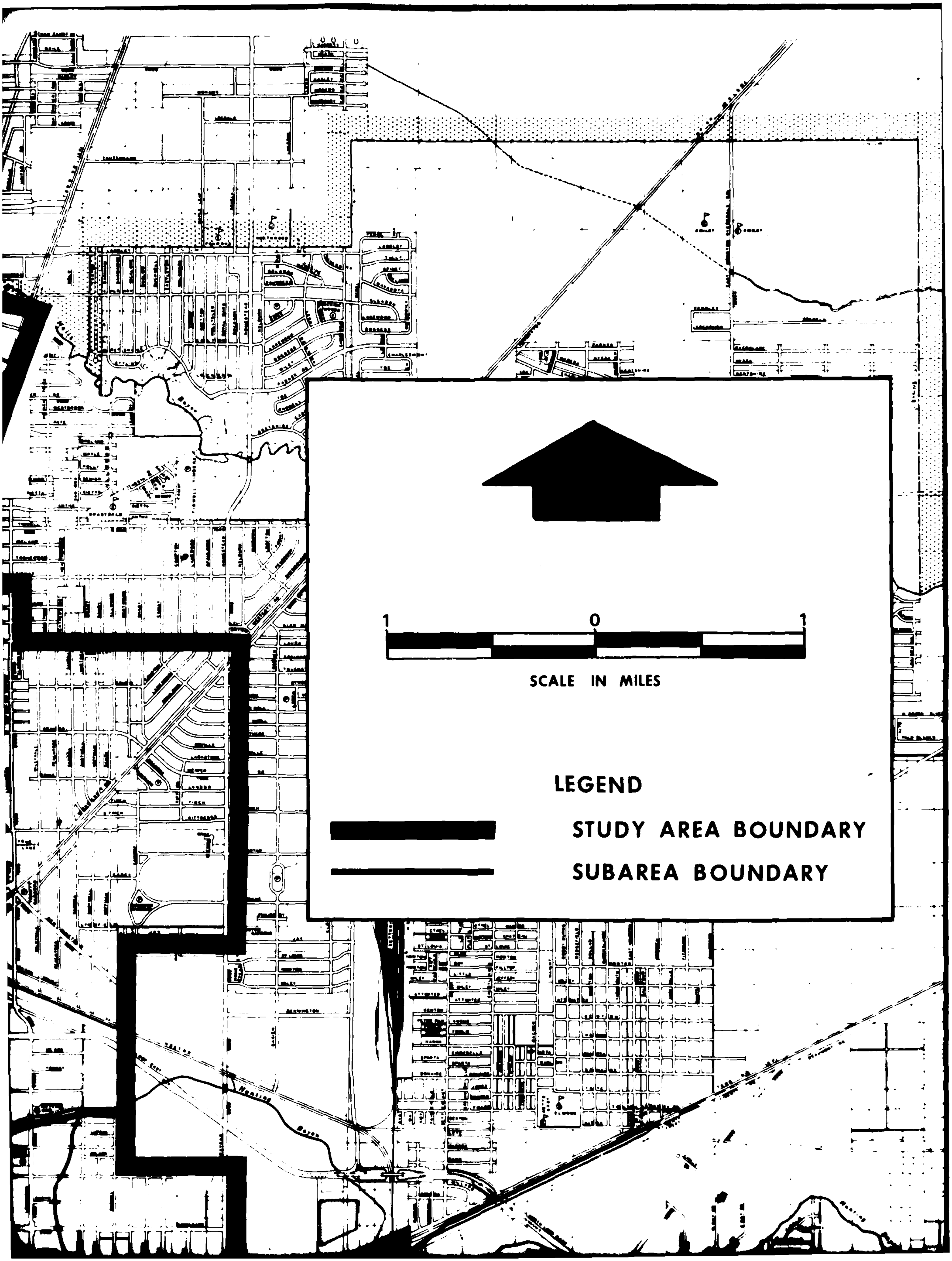
FREEWAY
H



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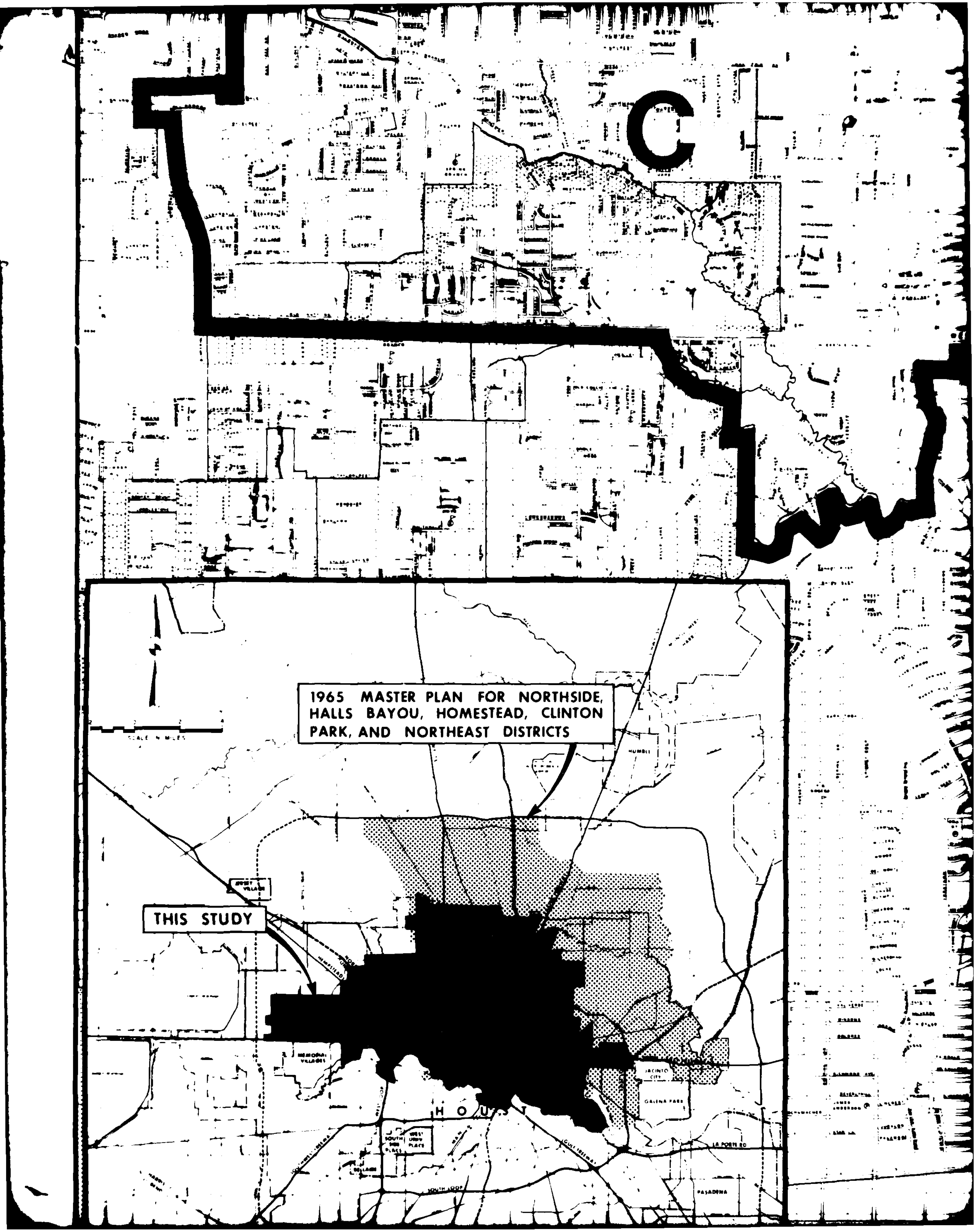
STUDY AREA BOUNDARY
SUBAREA BOUNDARY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1965 MASTER PLAN FOR NORTHSIDE, HALLS BAYOU, HOMESTEAD, CLINTON PARK, AND NORTHEAST DISTRICTS
THIS STUDY
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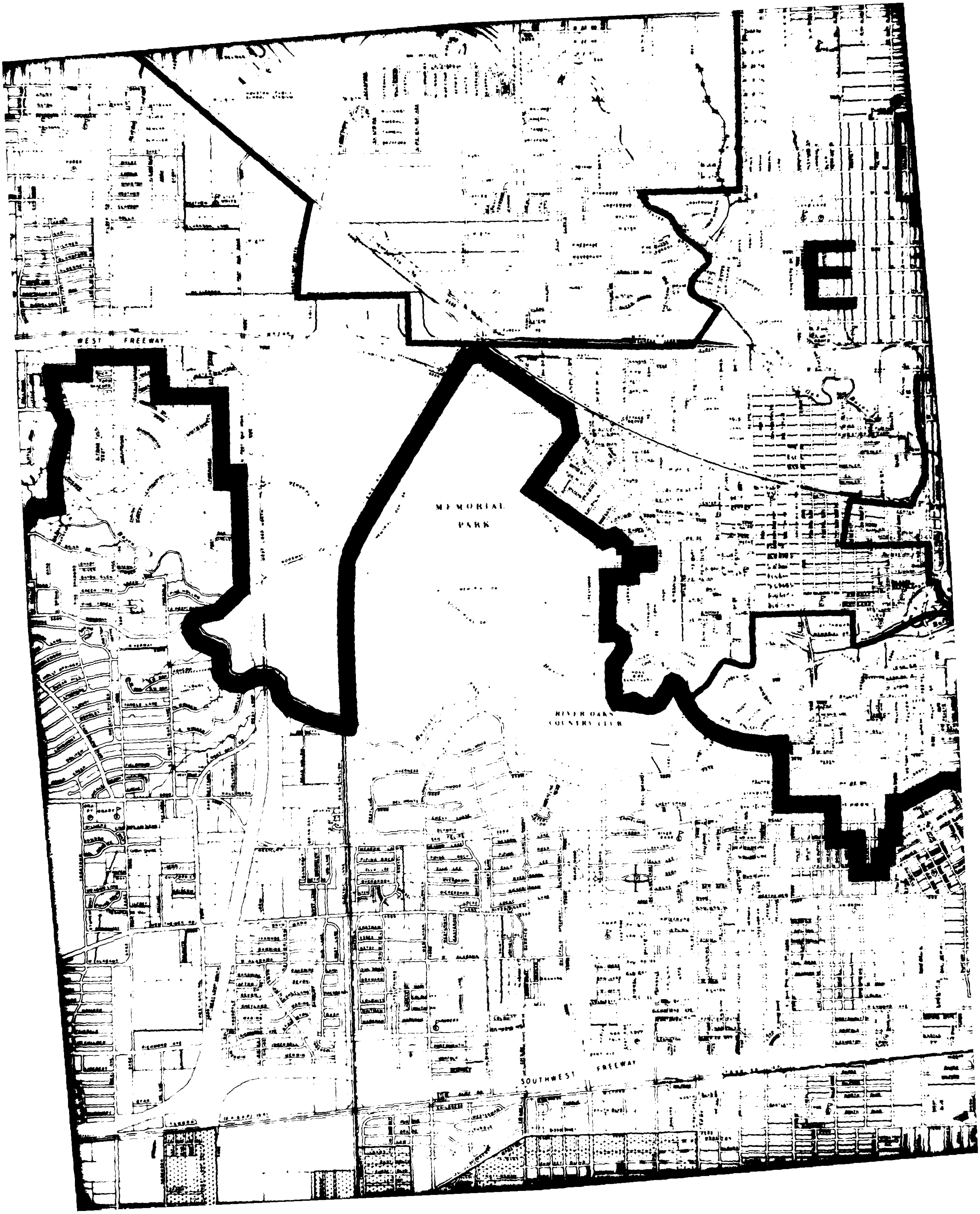
HEMPSTEAD
MEMORIAL VILLAGES
JACINTO CITY
GALENA PARK
LA PORTE RD
SOUTH LOOP
PASADENA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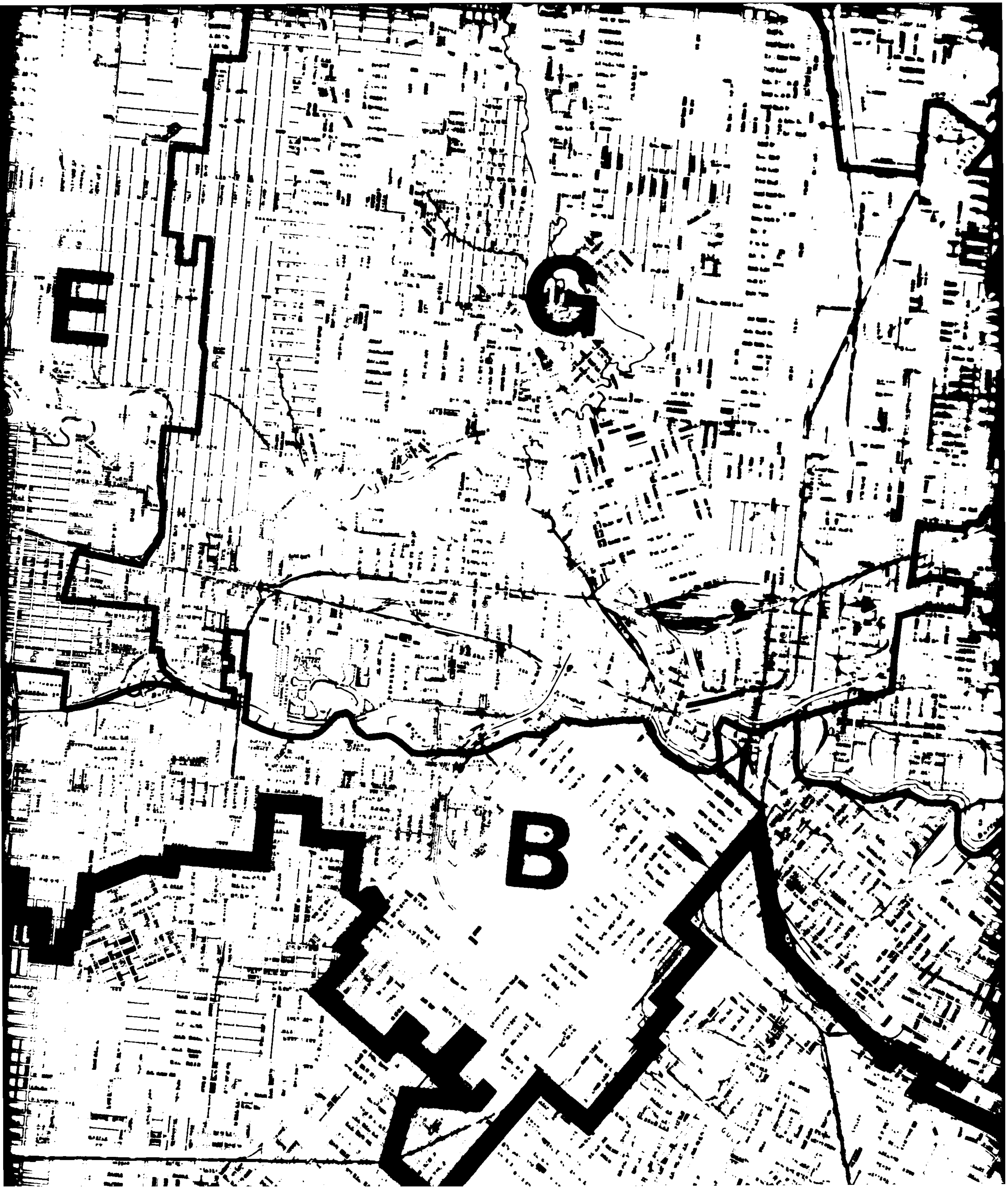
MEMORIAL
PARK
RIVER OAKS
COUNTRY CLUB
SOUTHWEST FREEWAY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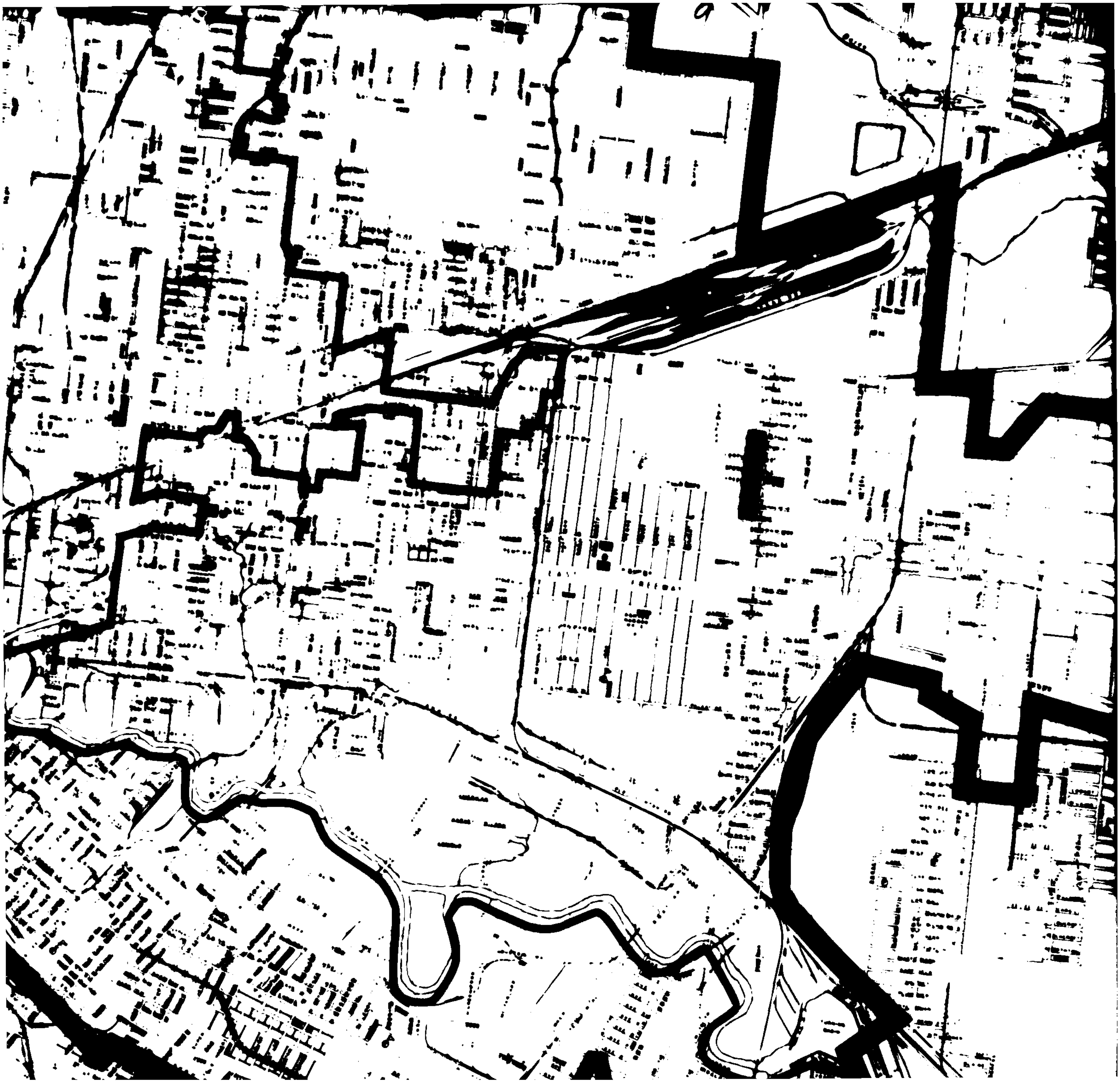

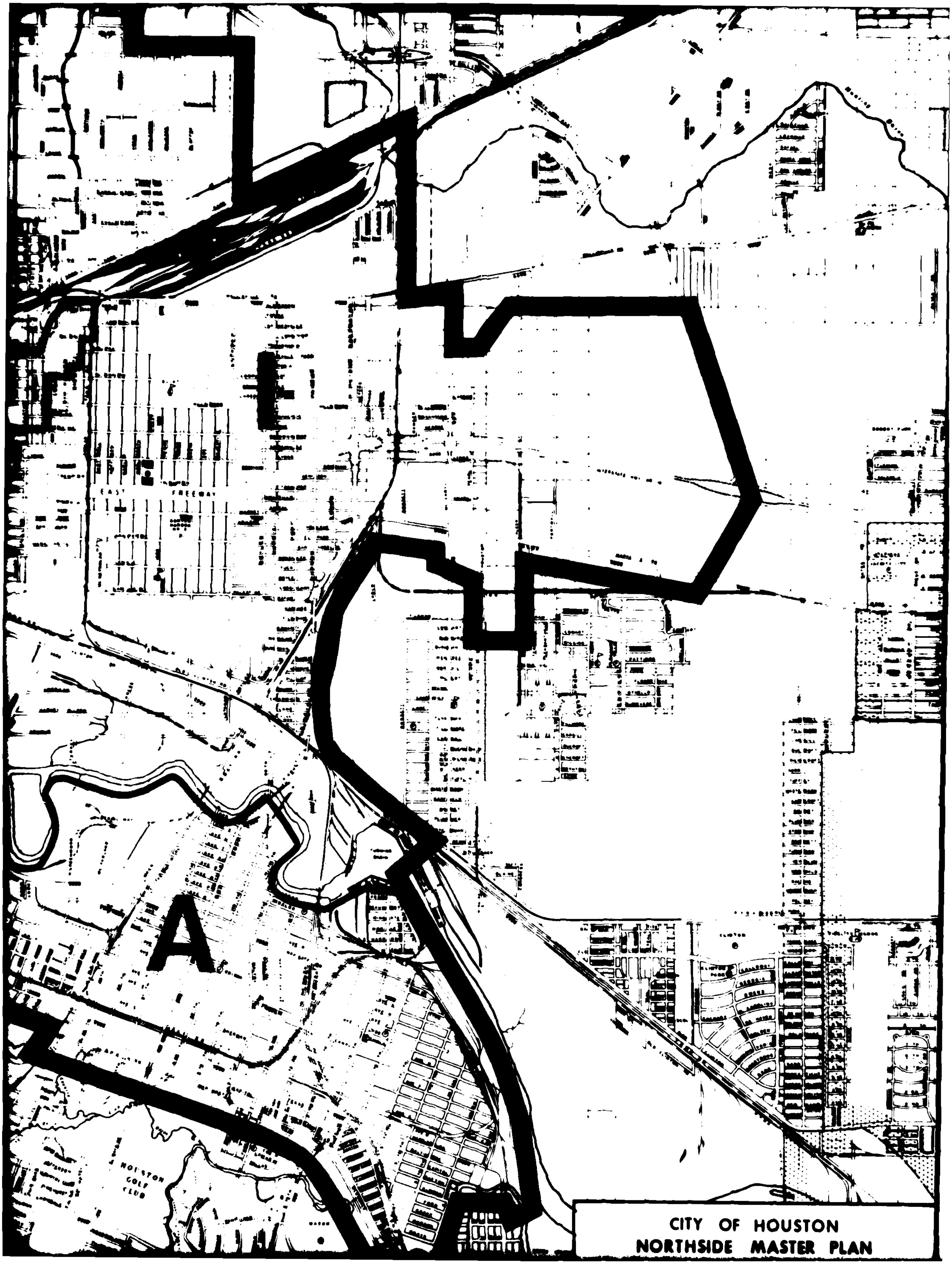
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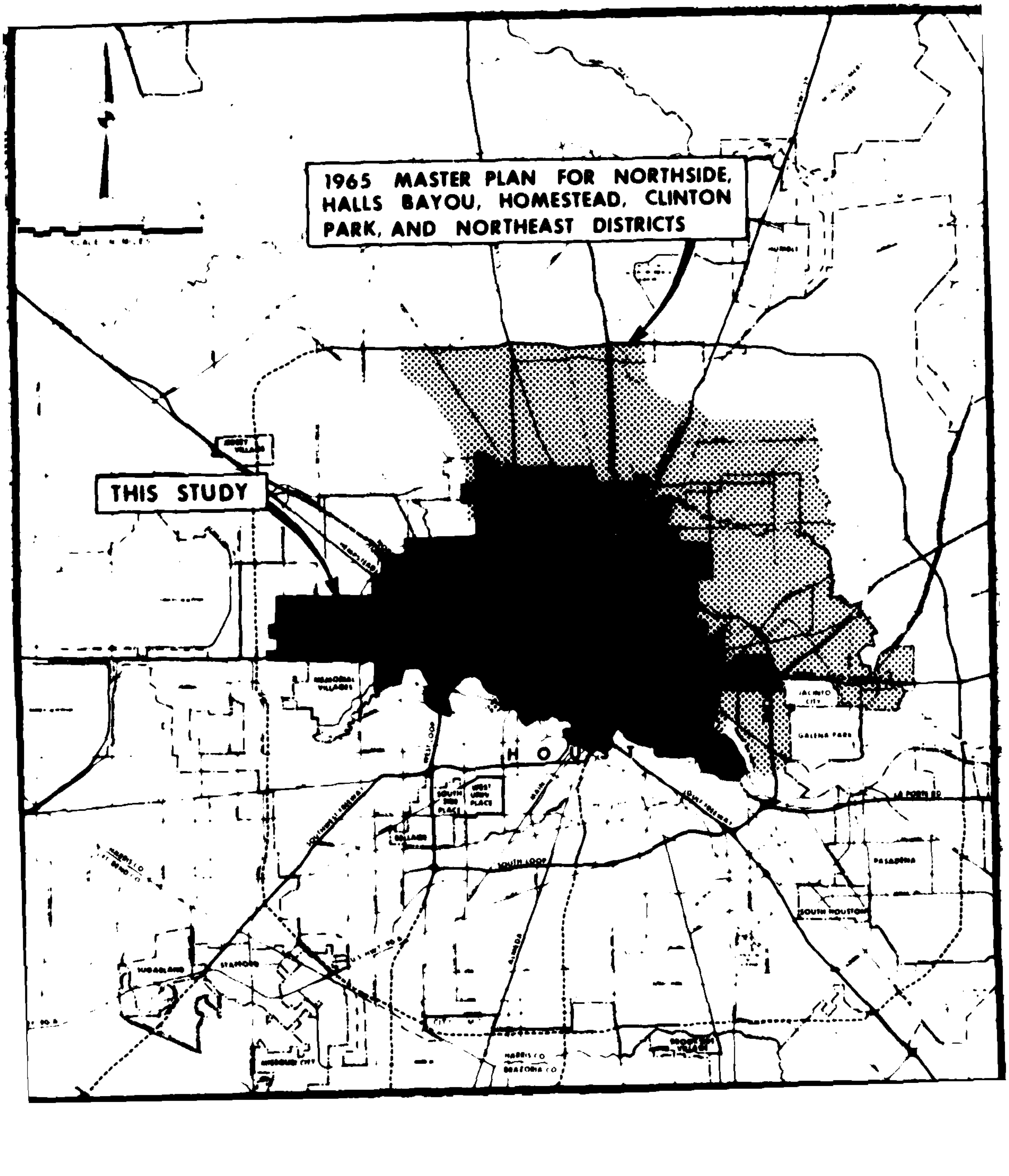
HOUSTON GOLF CLUB
CITY OF HOUSTON
NORTHSIDE MASTER PLAN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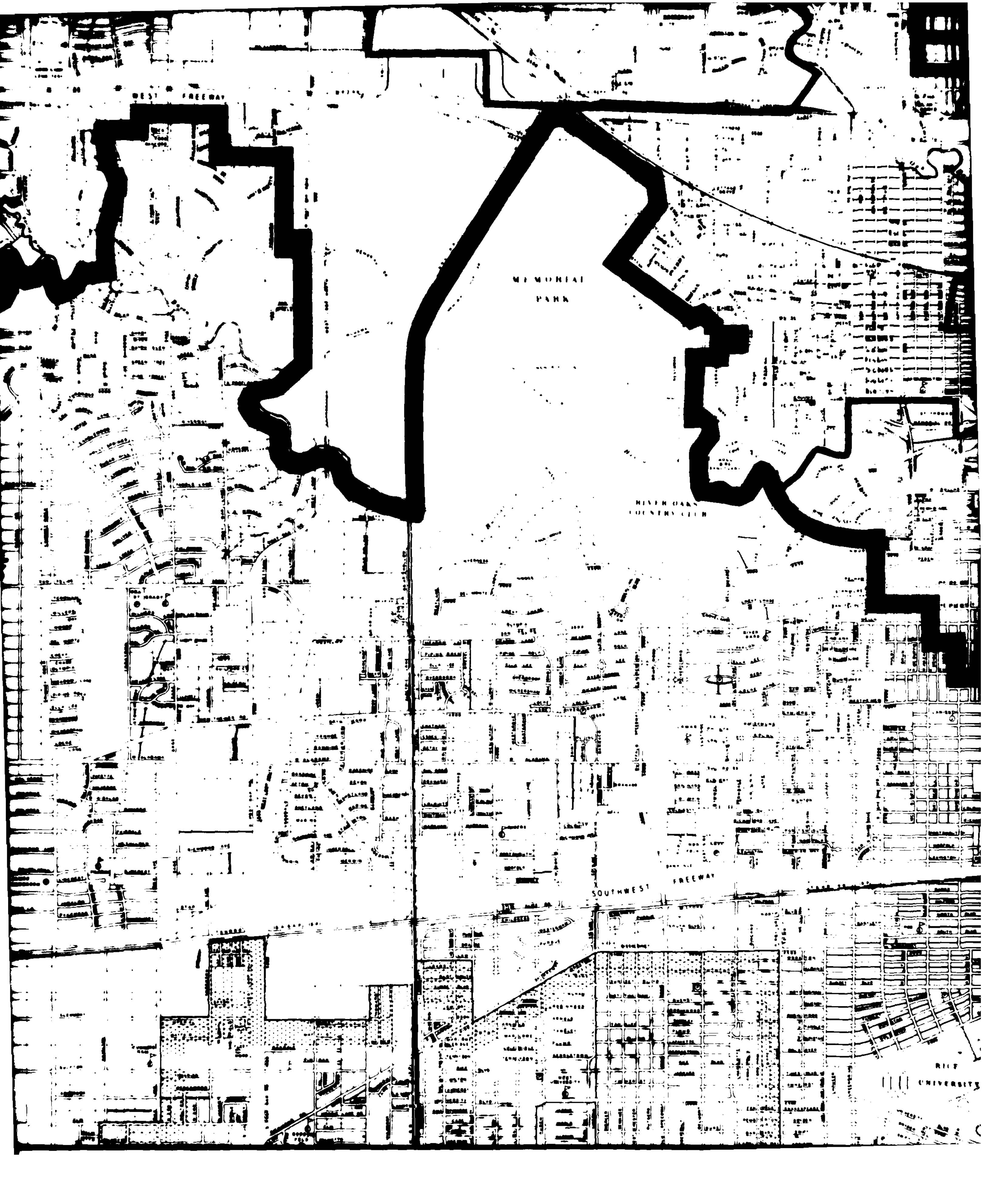
SOUTH HOUSTON
SOUTH LOOP
LA PORTE RD



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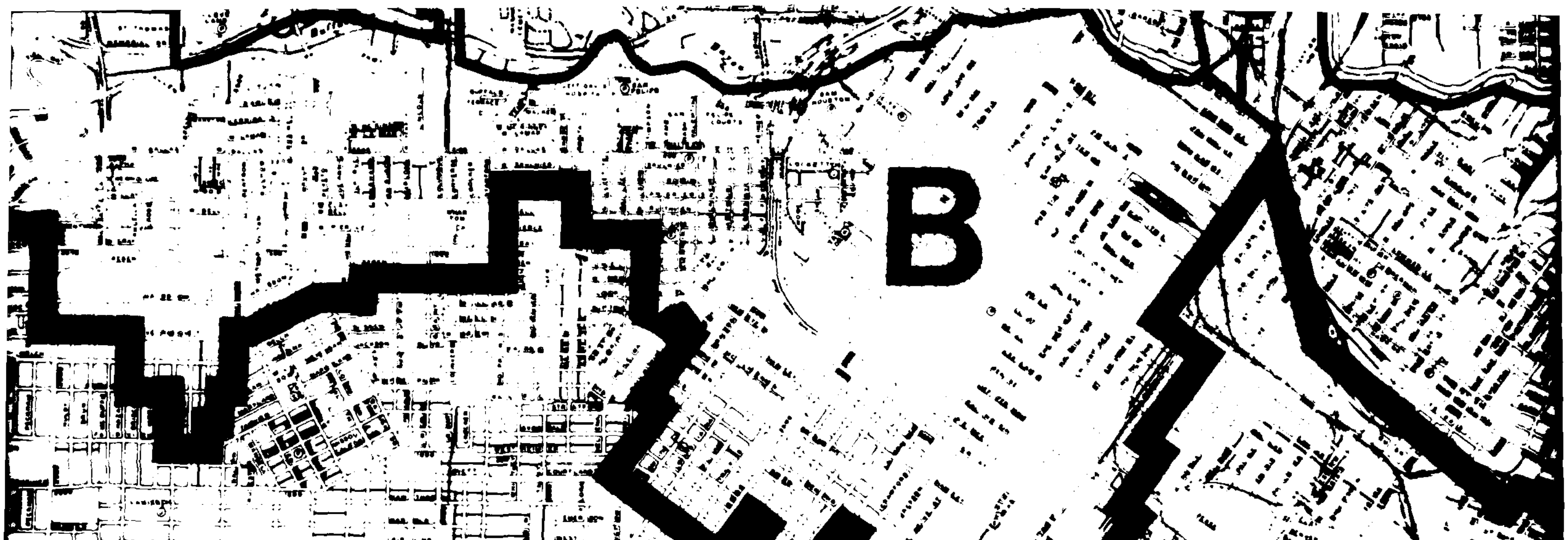
RIVER OAKS COUNTRY CLUB
SOUTHWEST FREEWAY
RICE UNIVERSITY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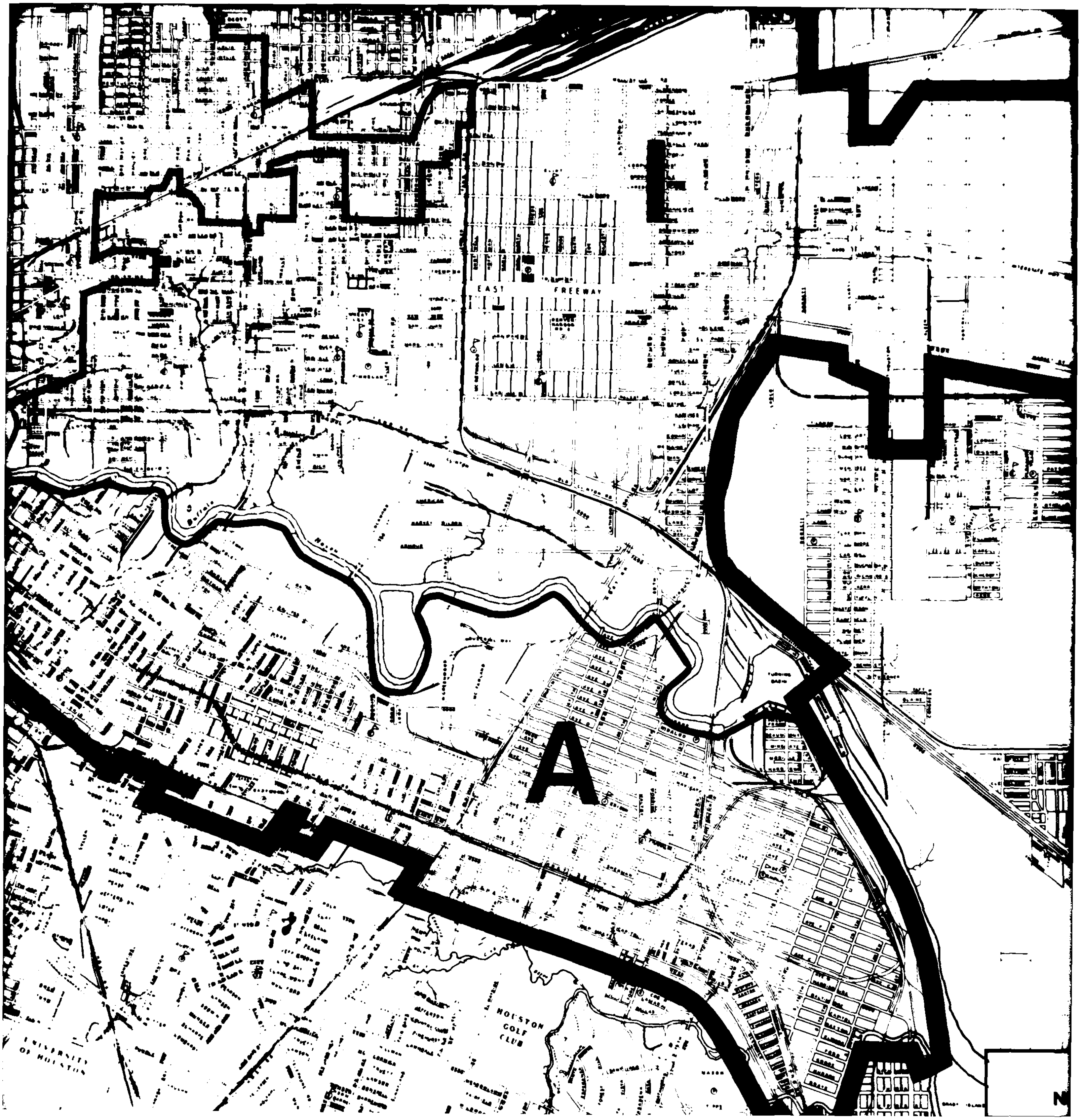
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A
HOUSTON
GOLF
CLUB
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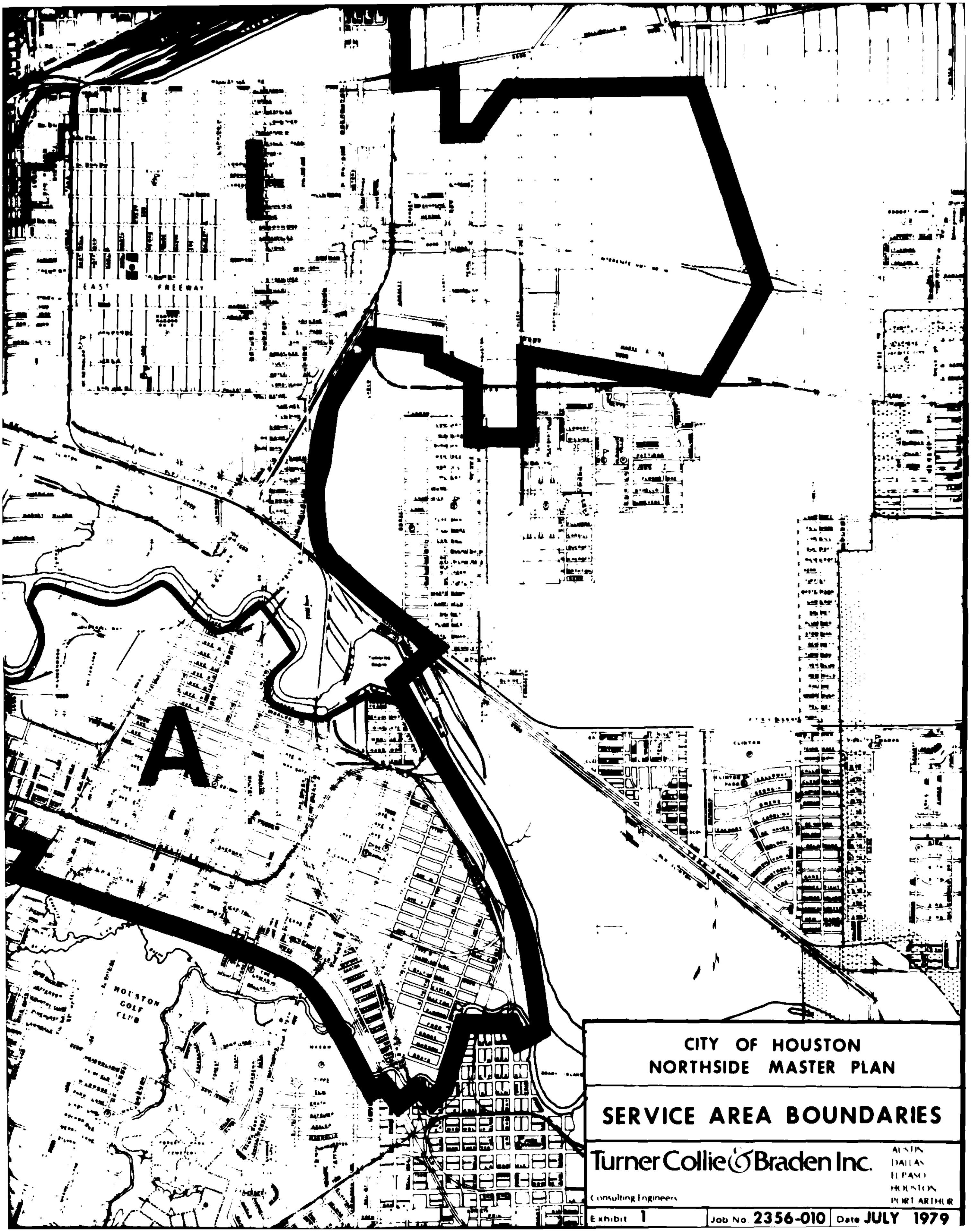
OF HOUSTON

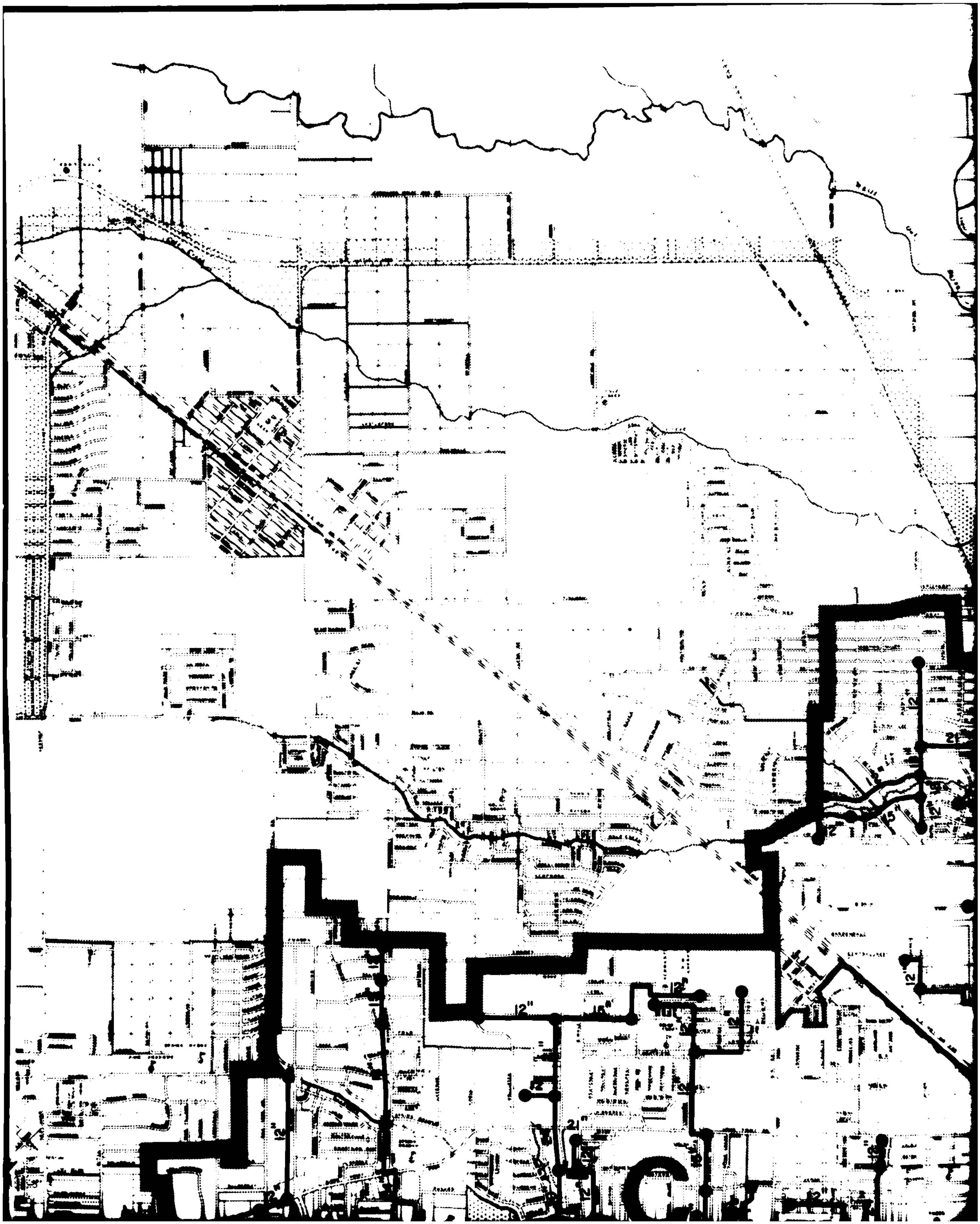


CITY OF HOUSTON
NORTHSIDE MASTER PLAN

SERVICE AREA BOUNDARIES

Turner Collie & Braden Inc.
AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR
Consulting Engineers

Exhibit 1 | Job No. 2356-010 | Date JULY 1979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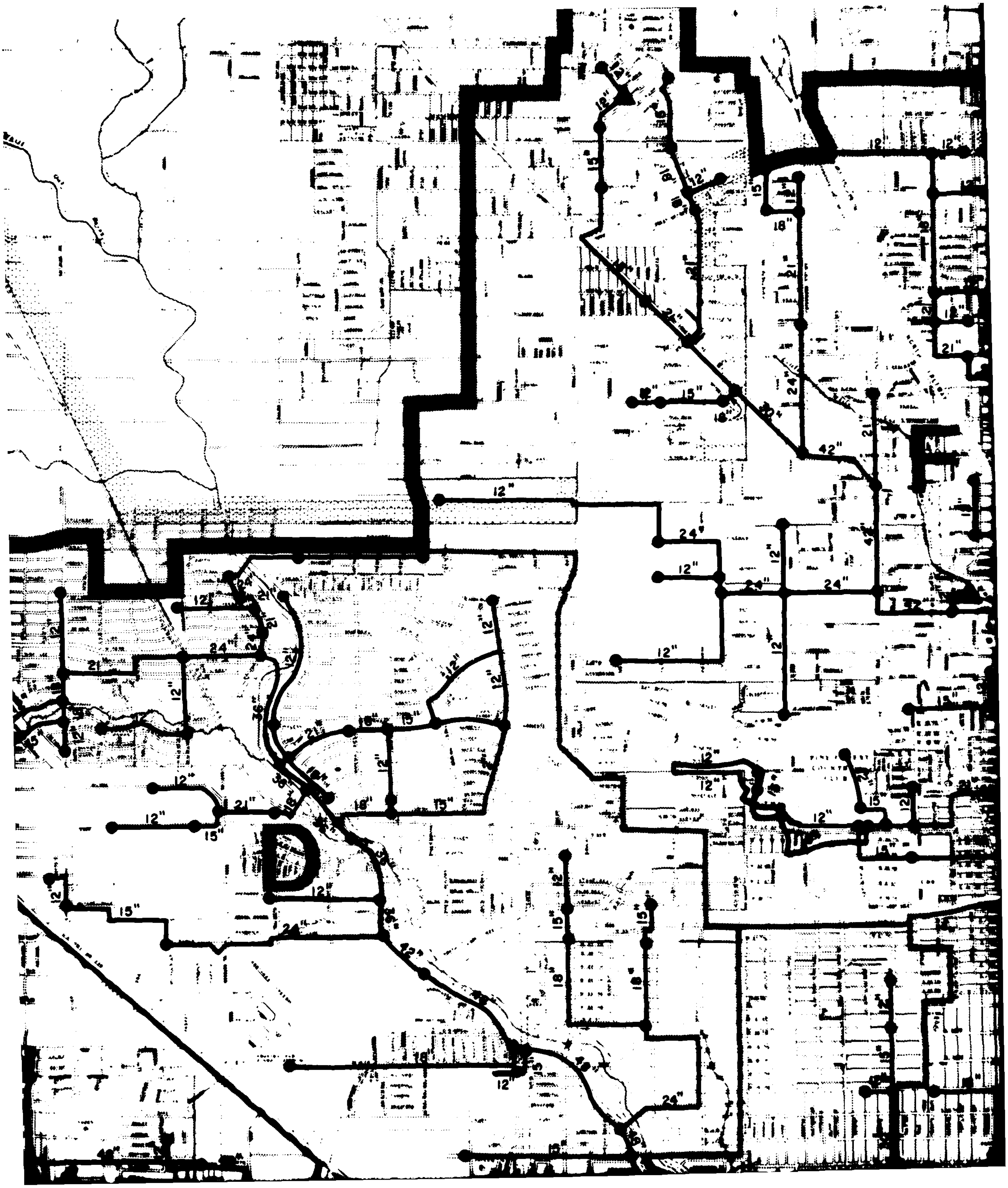
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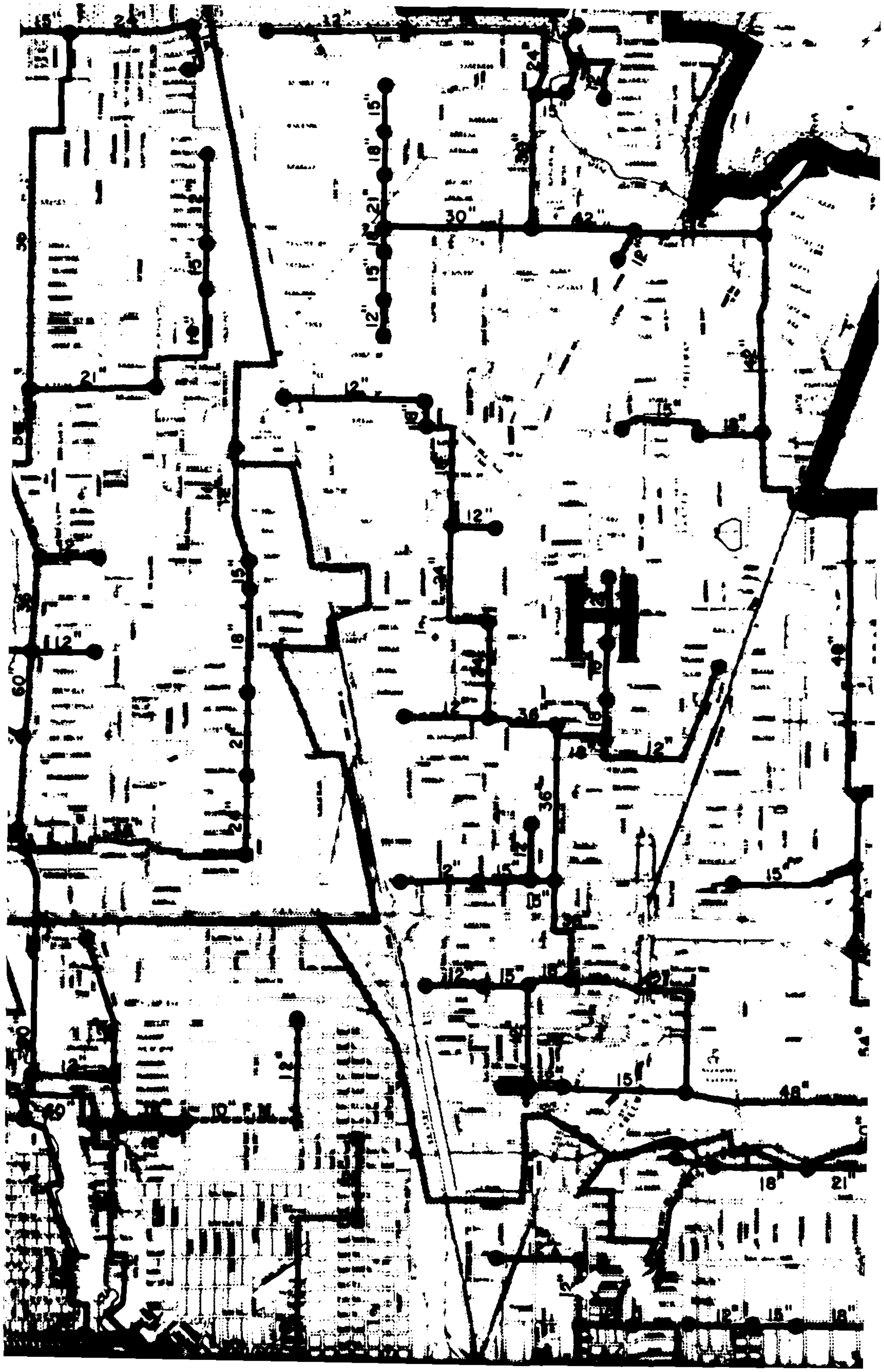

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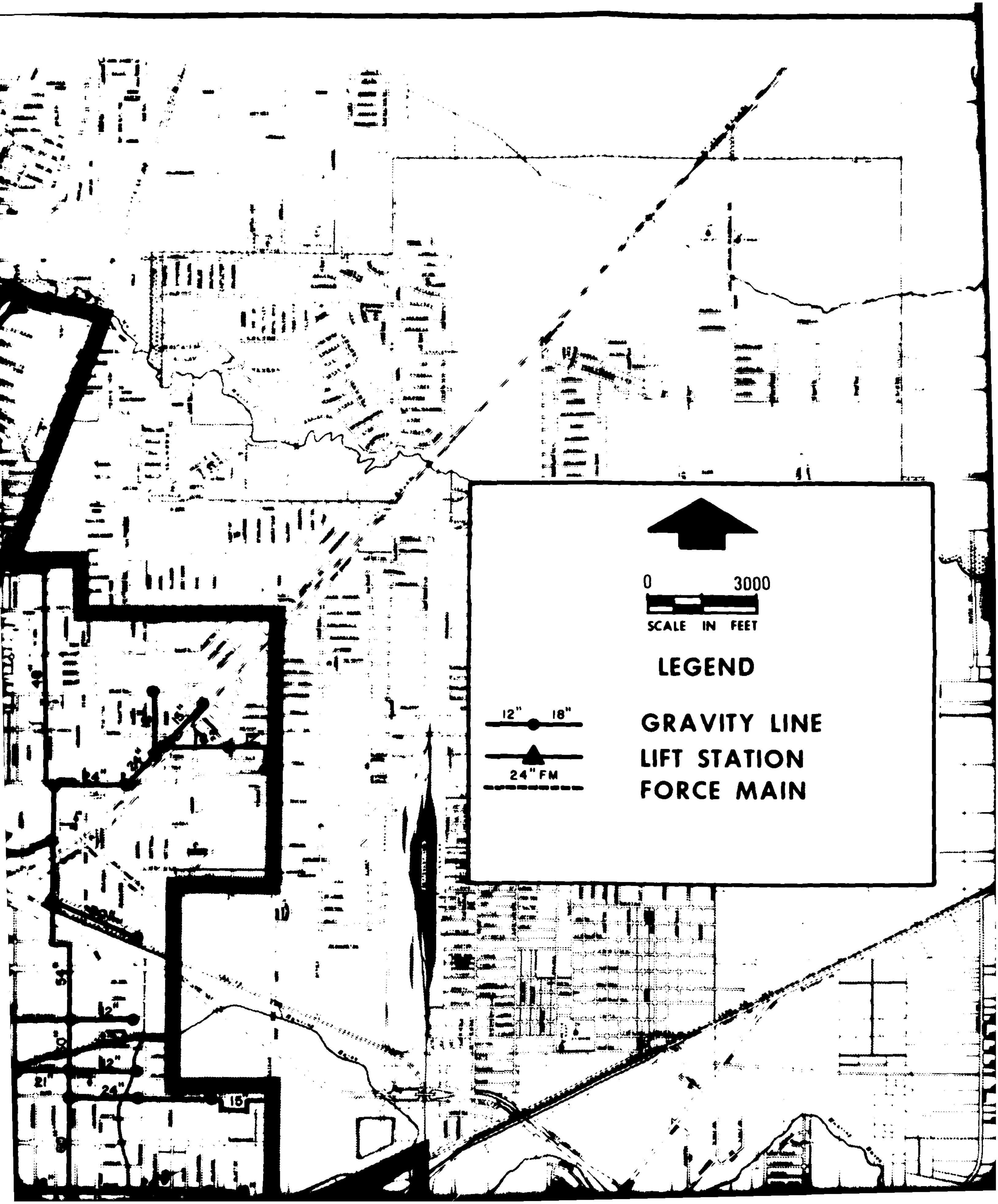
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24" FM
FORCE MAIN
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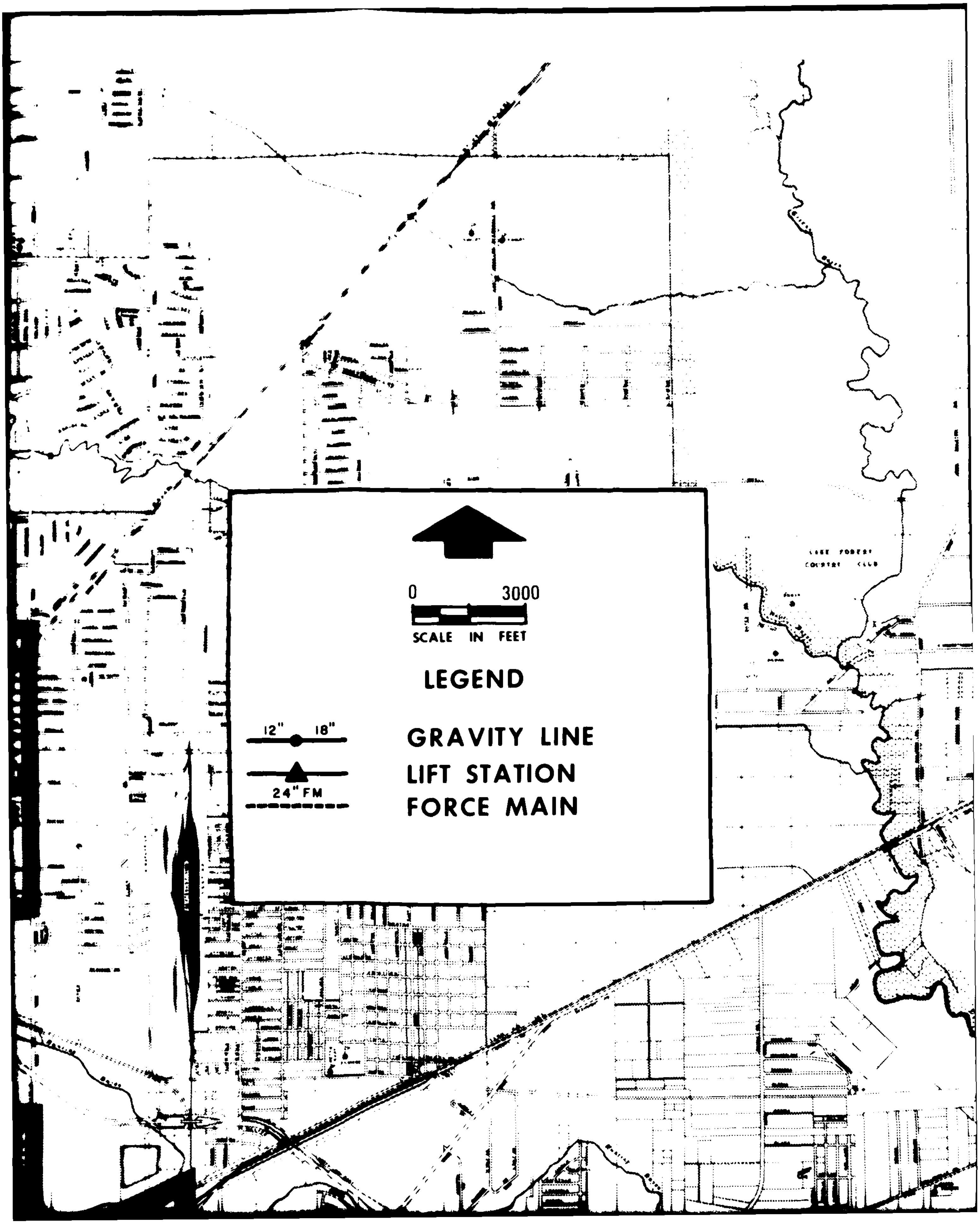
24"
15



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GRAVITY LINE
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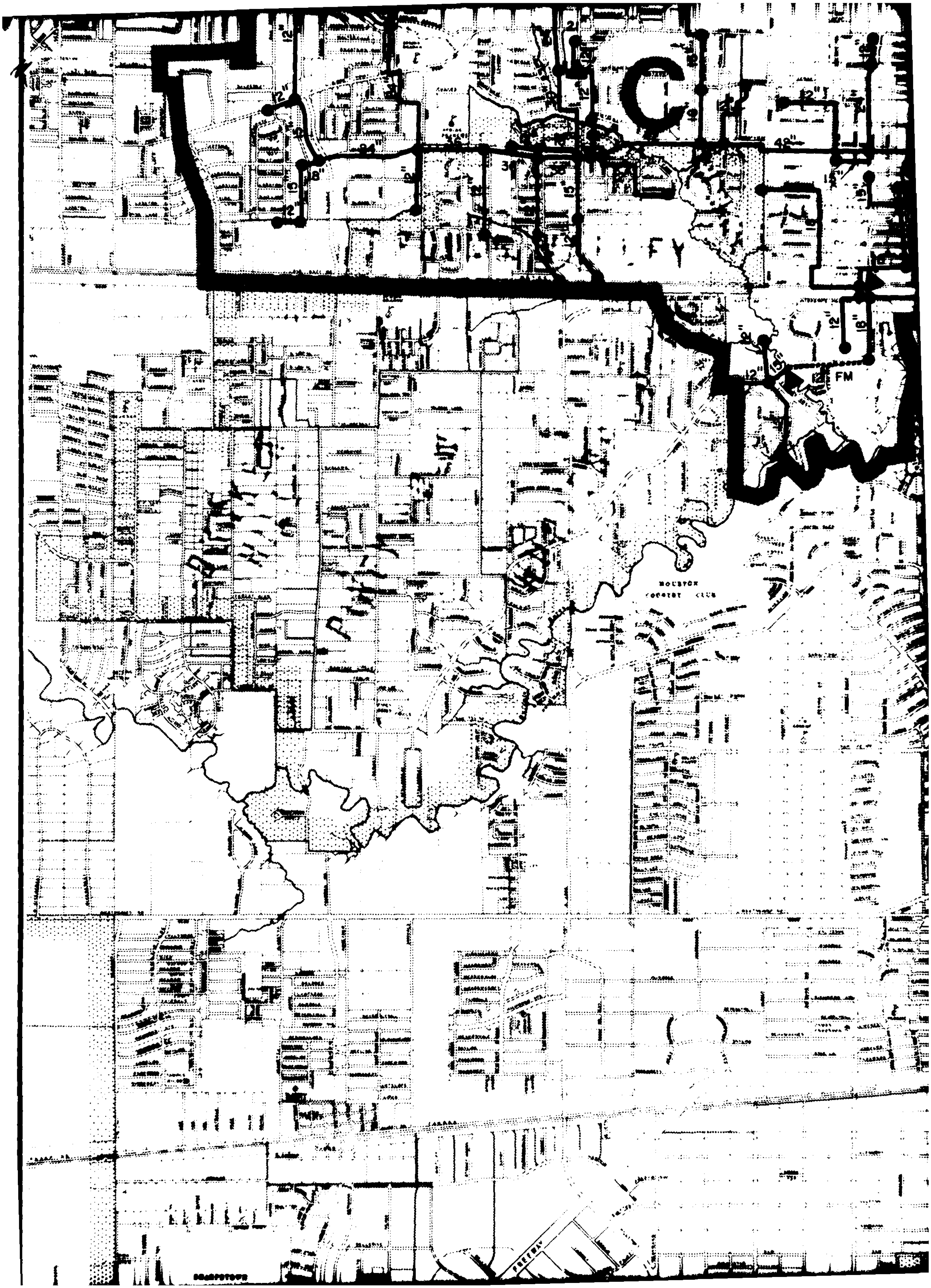
FORCE MAIN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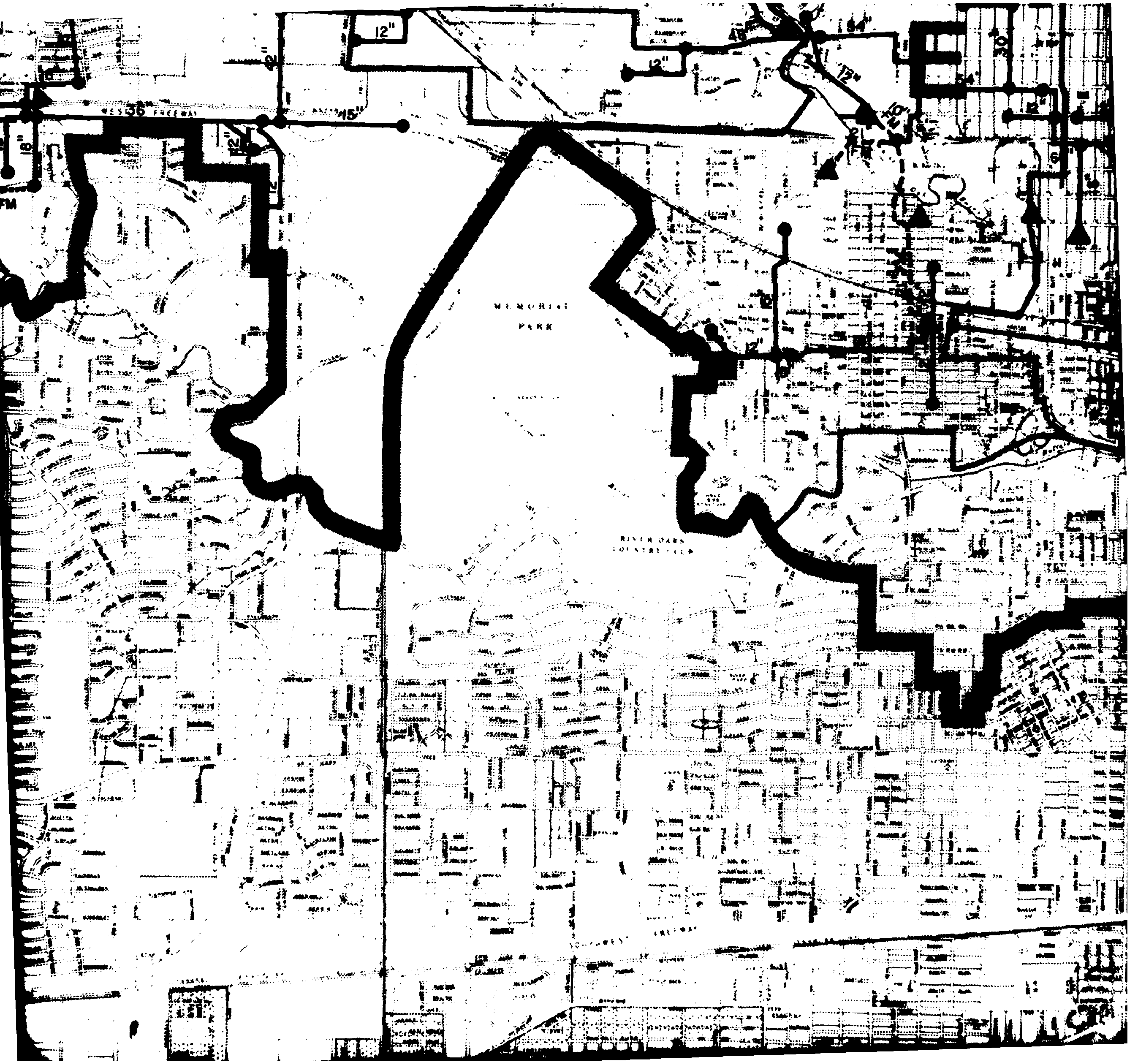

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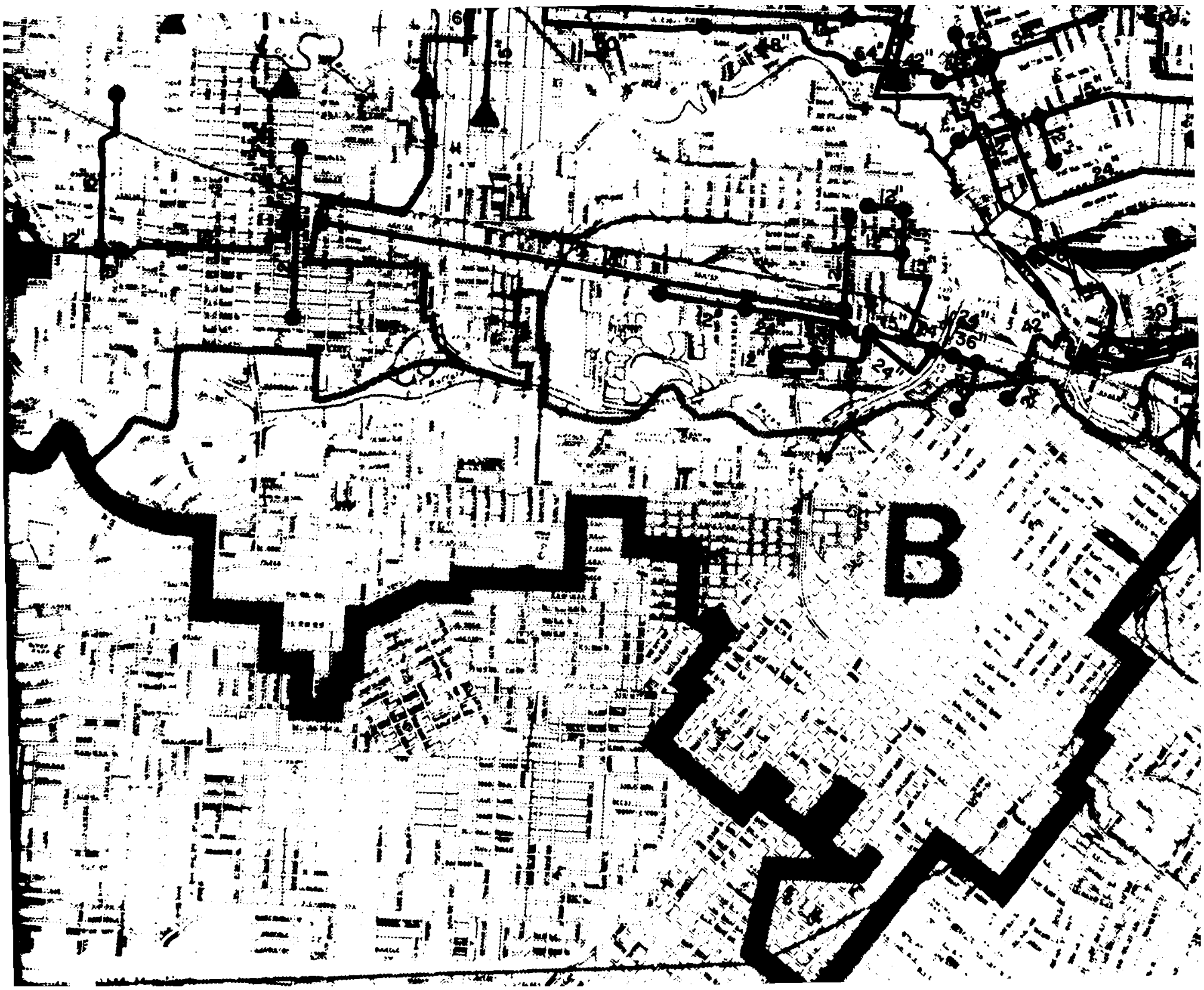
MEMORIAL PARK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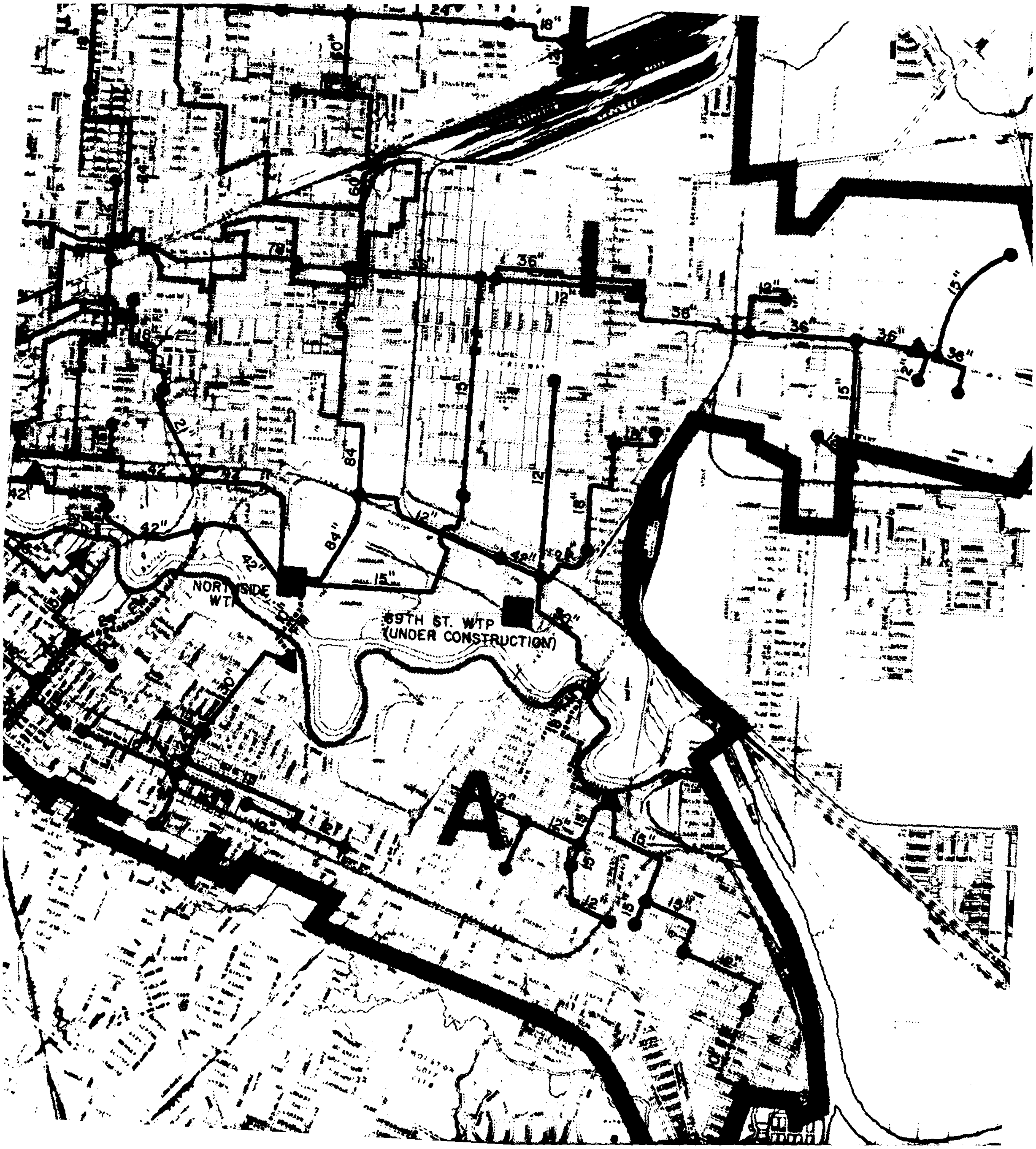

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69TH ST. WTP
(UNDER CONSTRUCTION)
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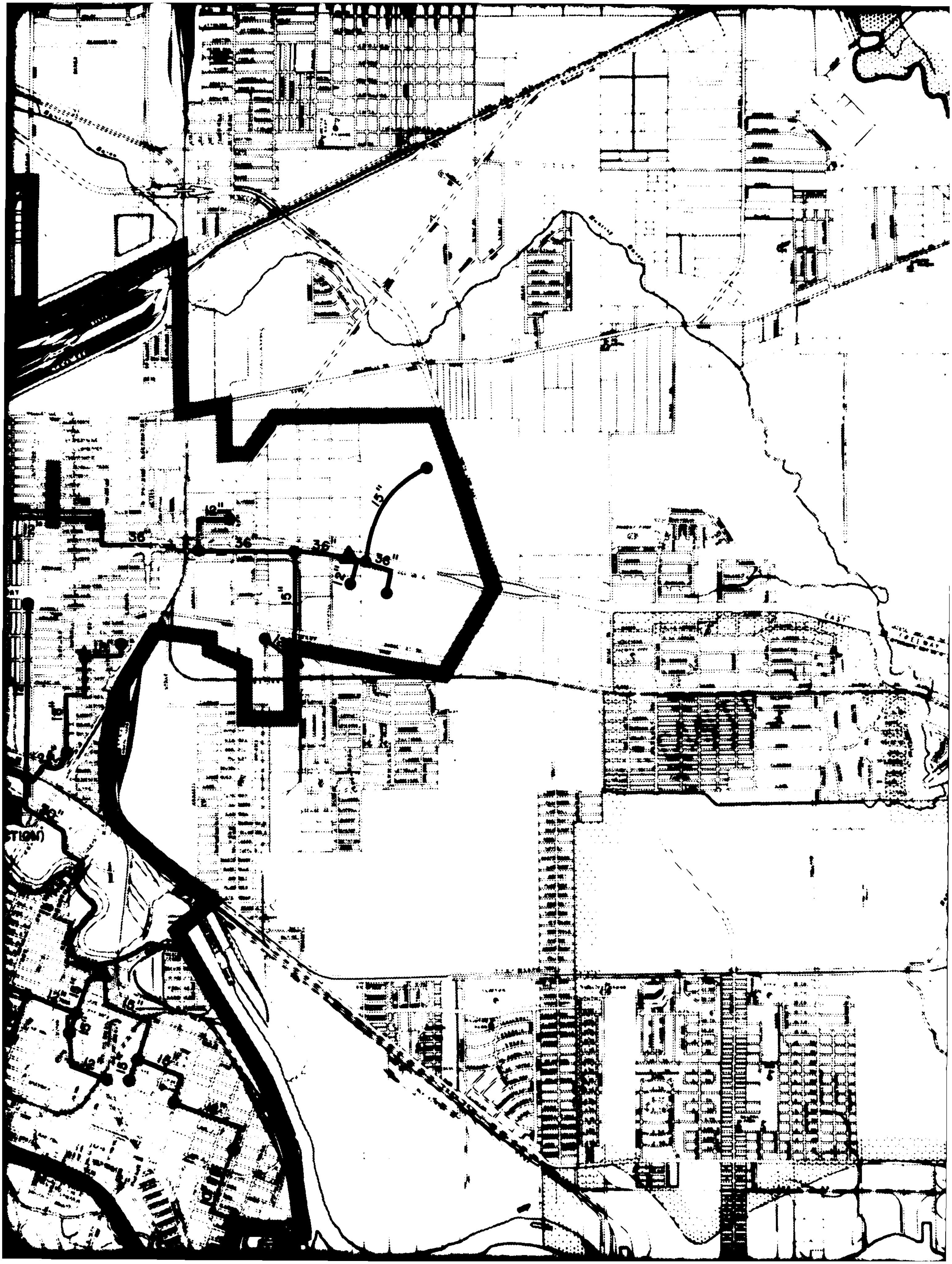
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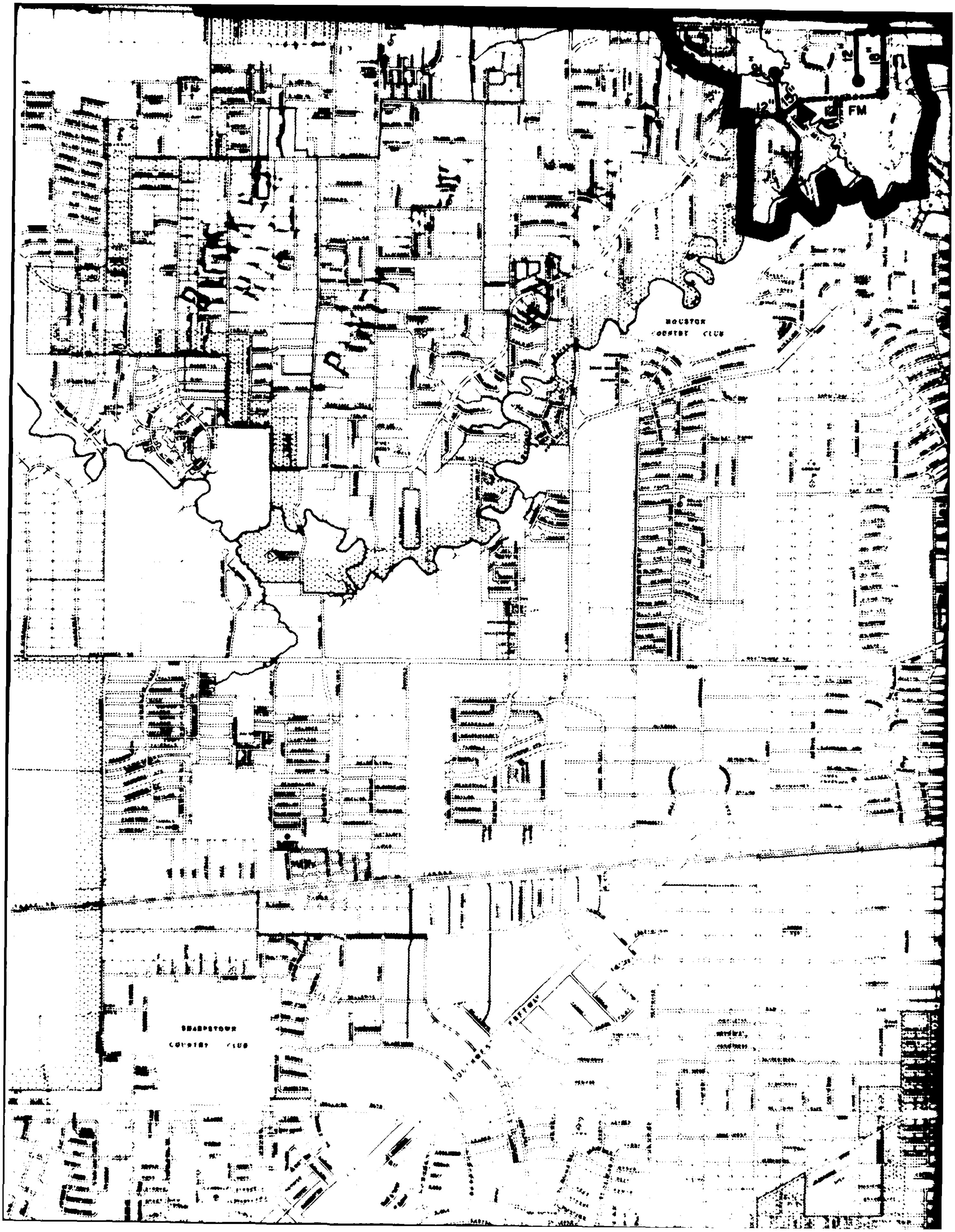
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HOUSTON COUNTRY CLUB
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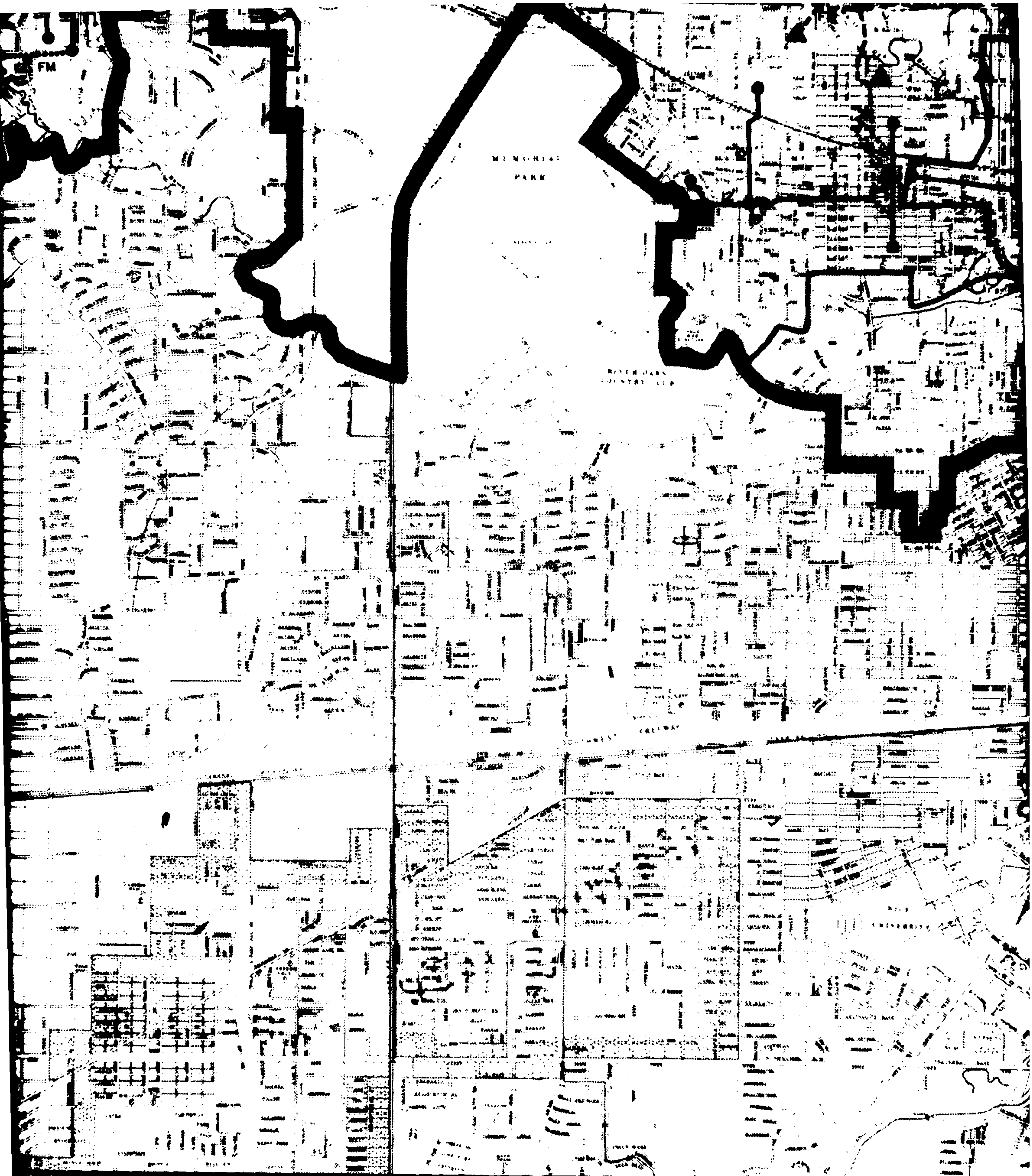
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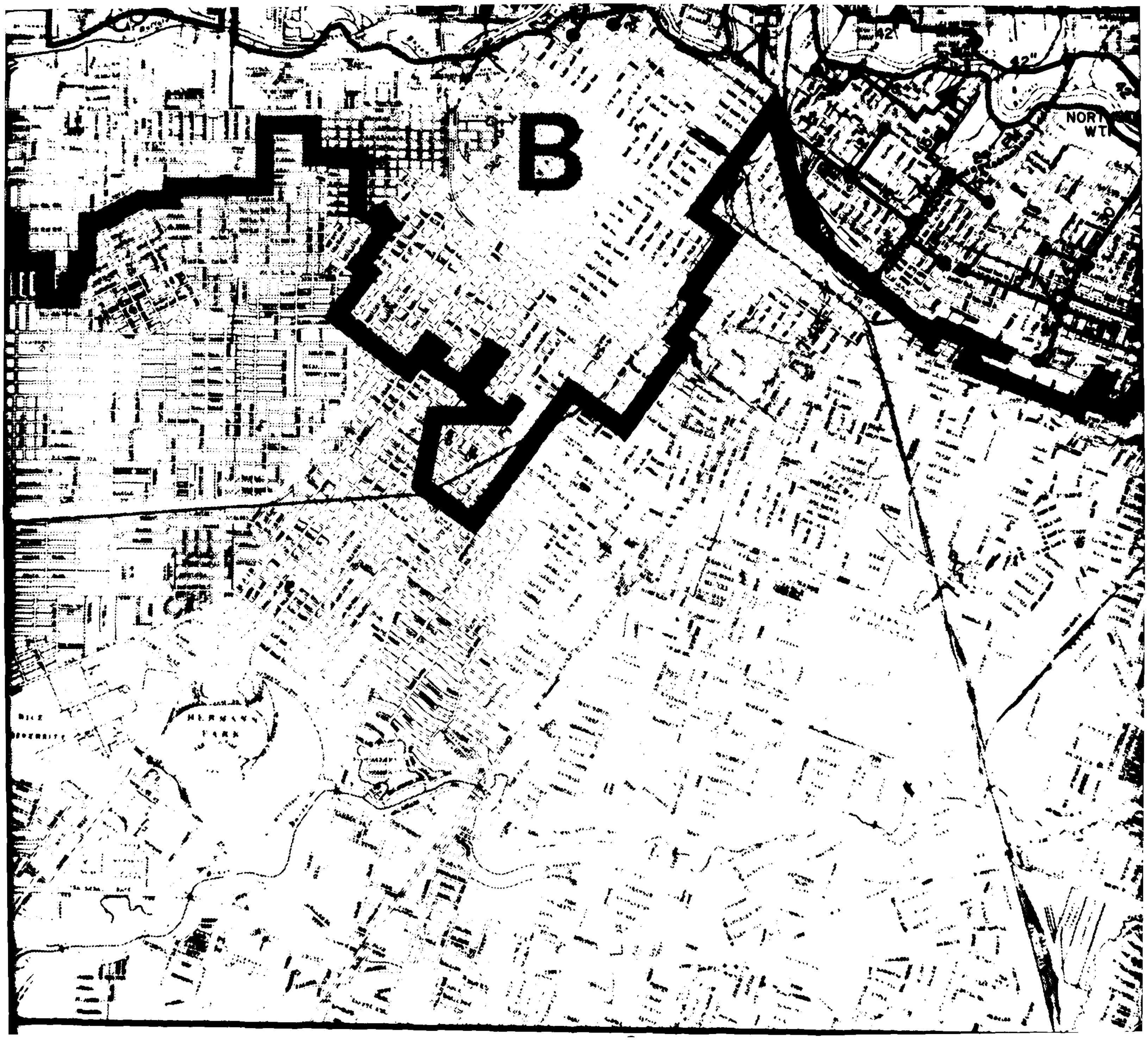
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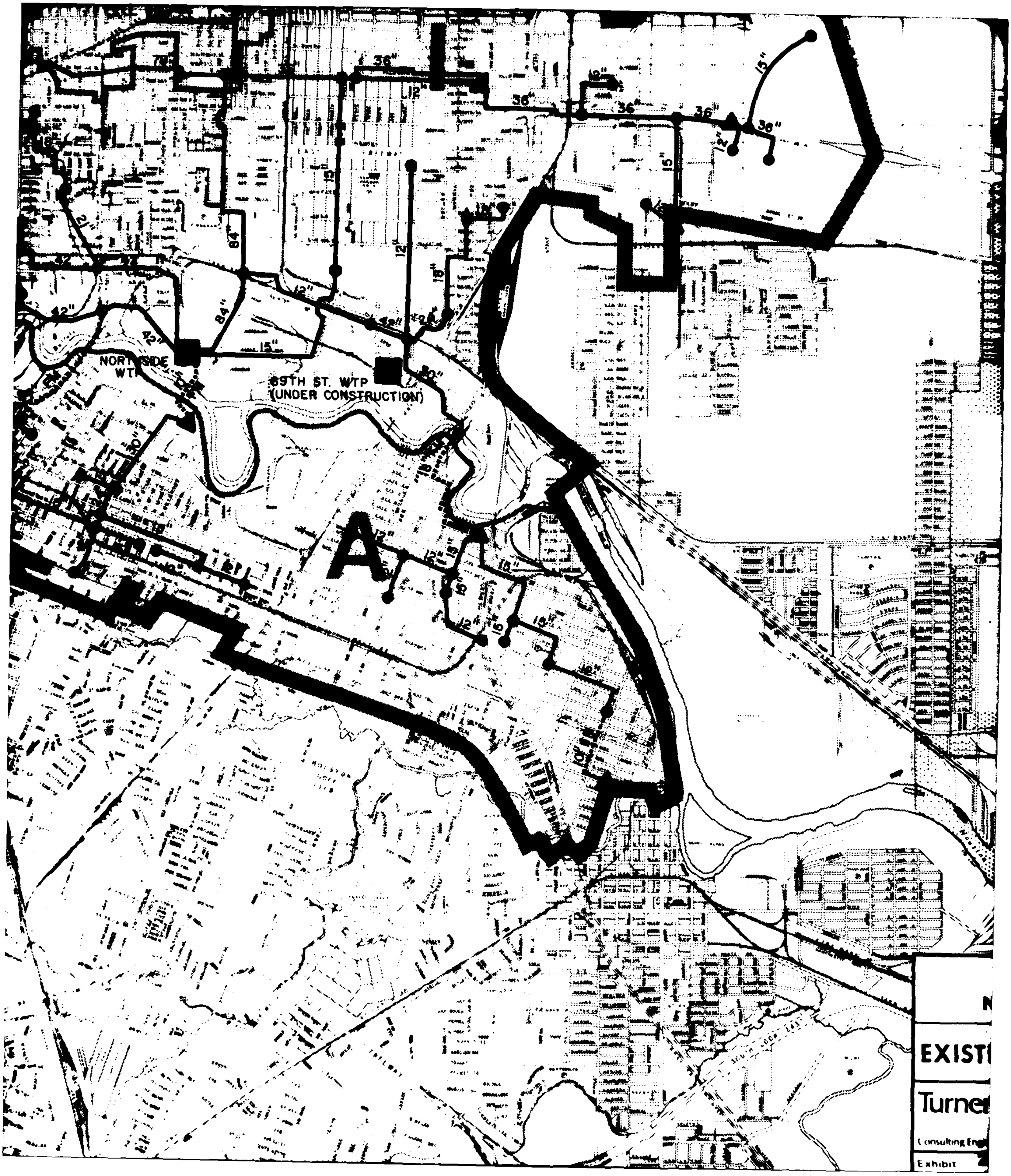
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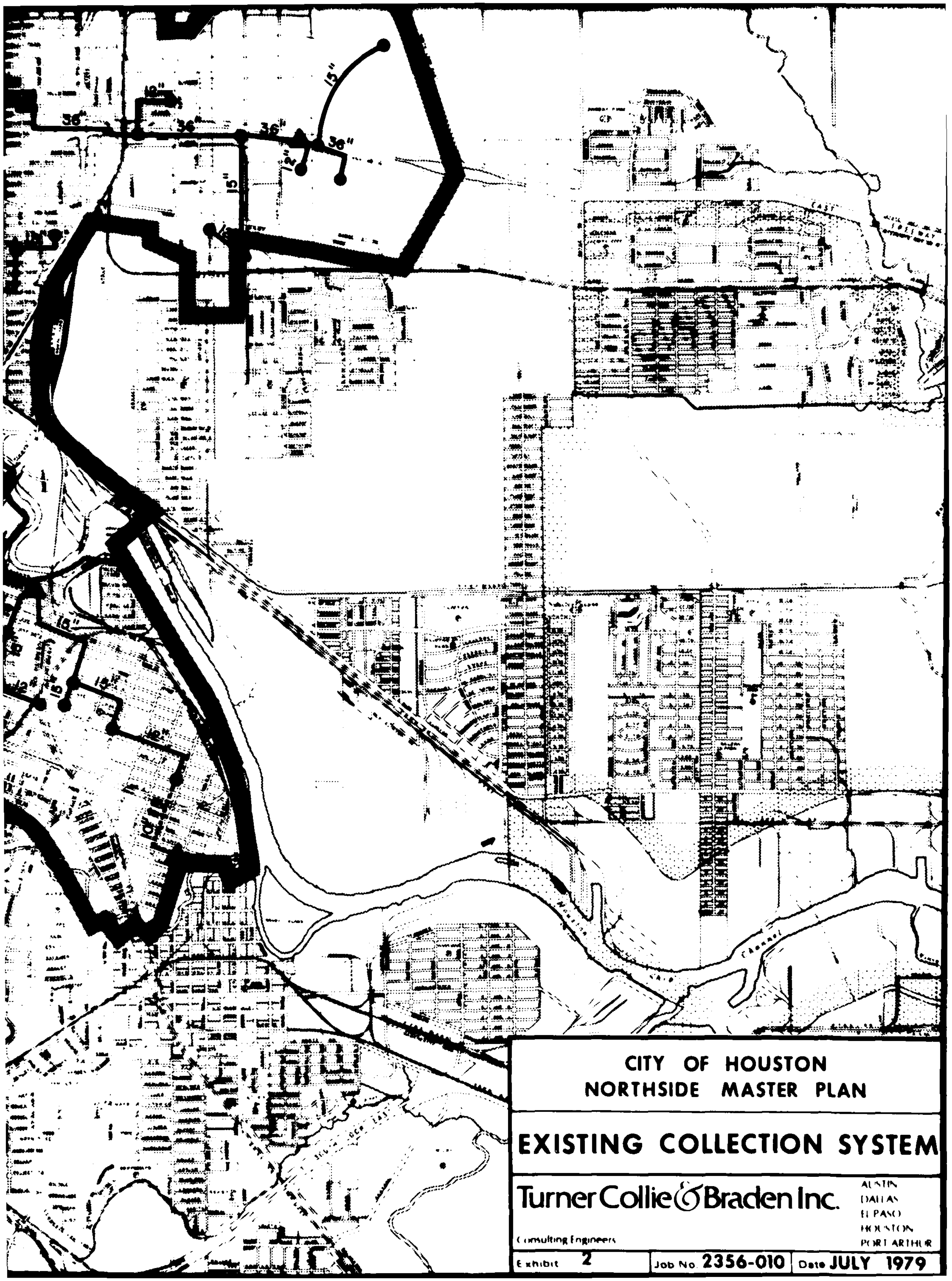
Consulting Eng
Exhibit



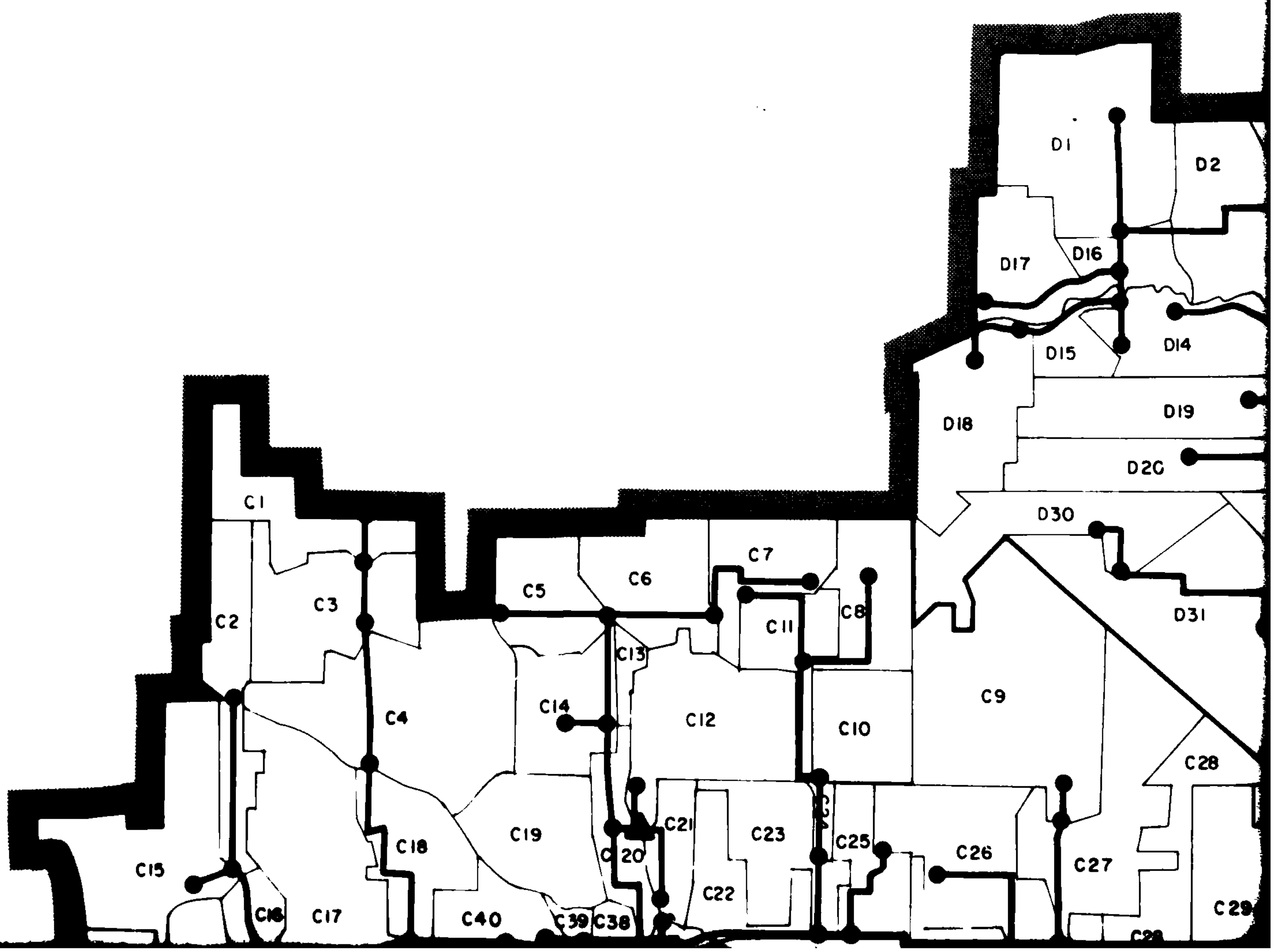
CITY OF HOUSTON
NORTHSIDE MASTER PLAN

EXISTING COLLECTION SYSTEM

Turner Collie & Braden Inc.
Consulting Engineers

AUSTIN
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 2 | Job No. 2356-010 | Date JULY 1979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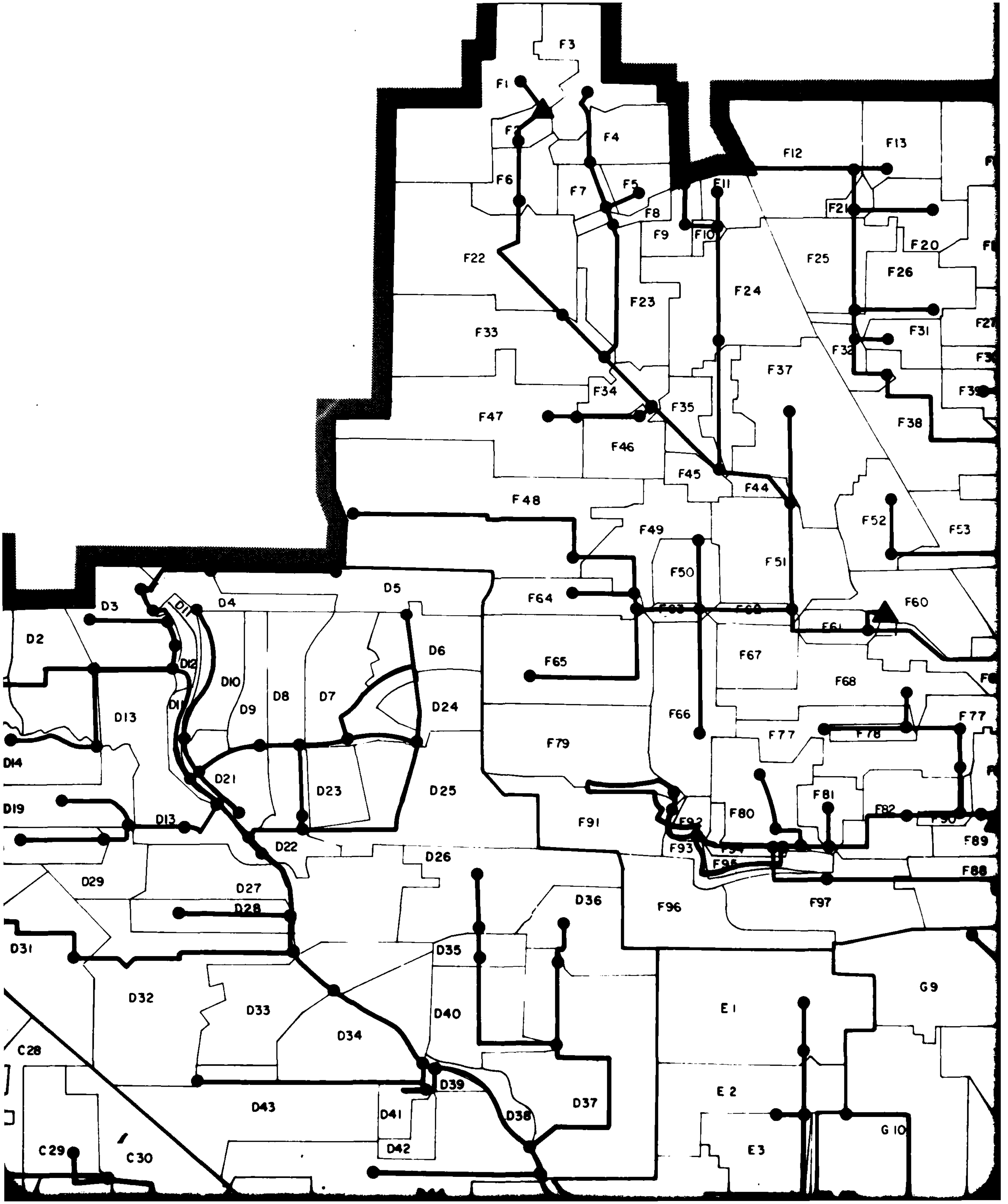
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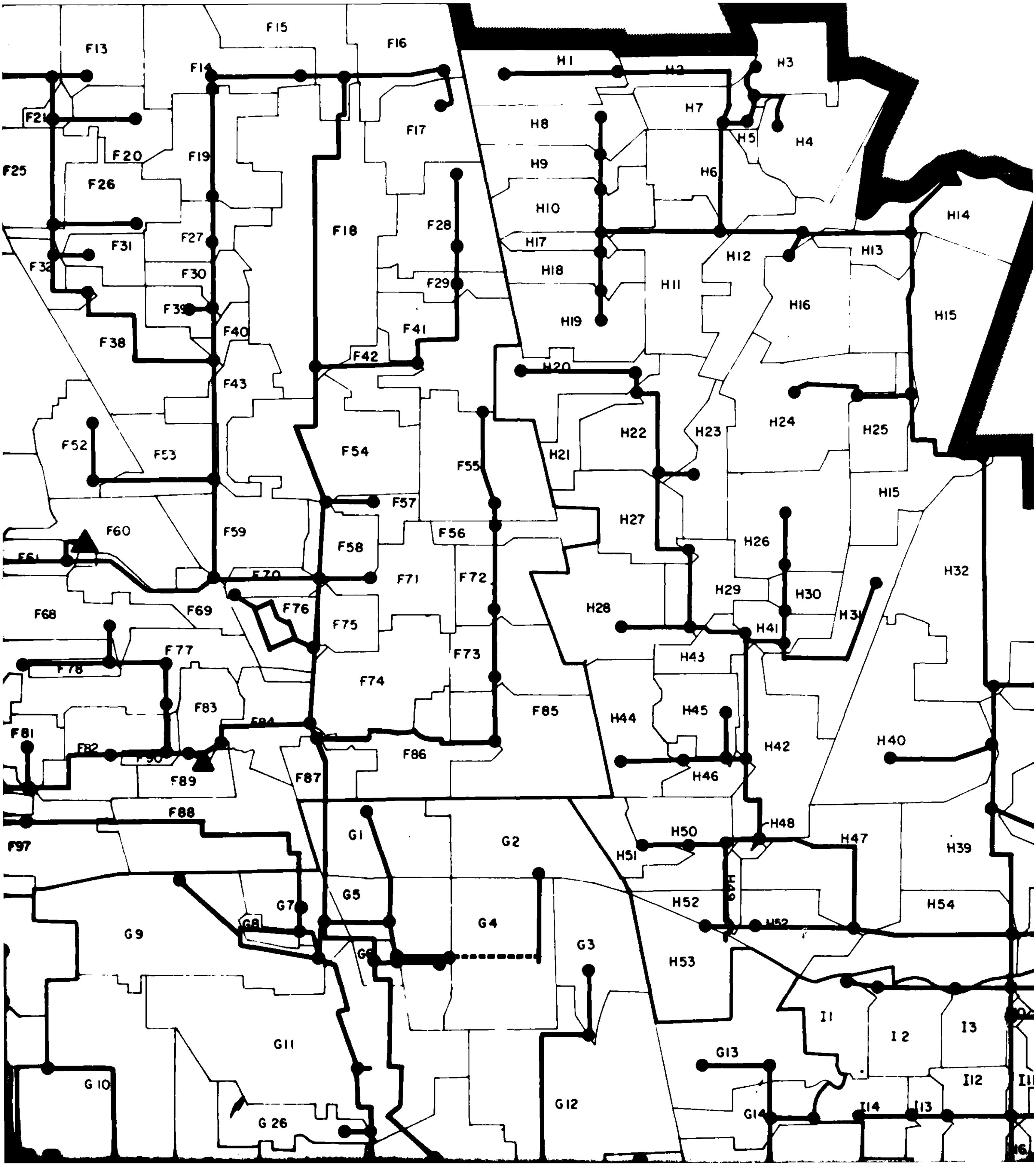

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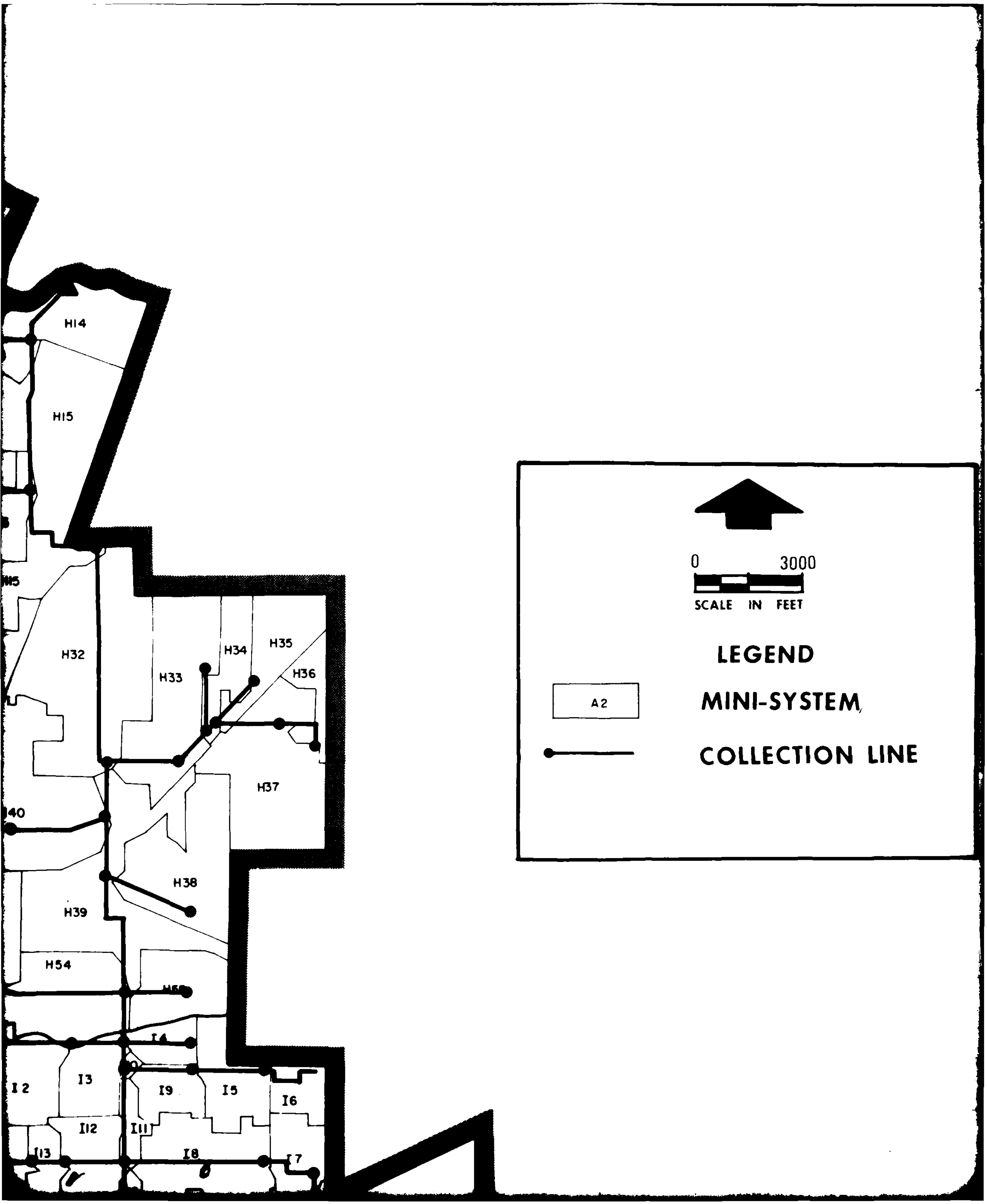
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LEGEND
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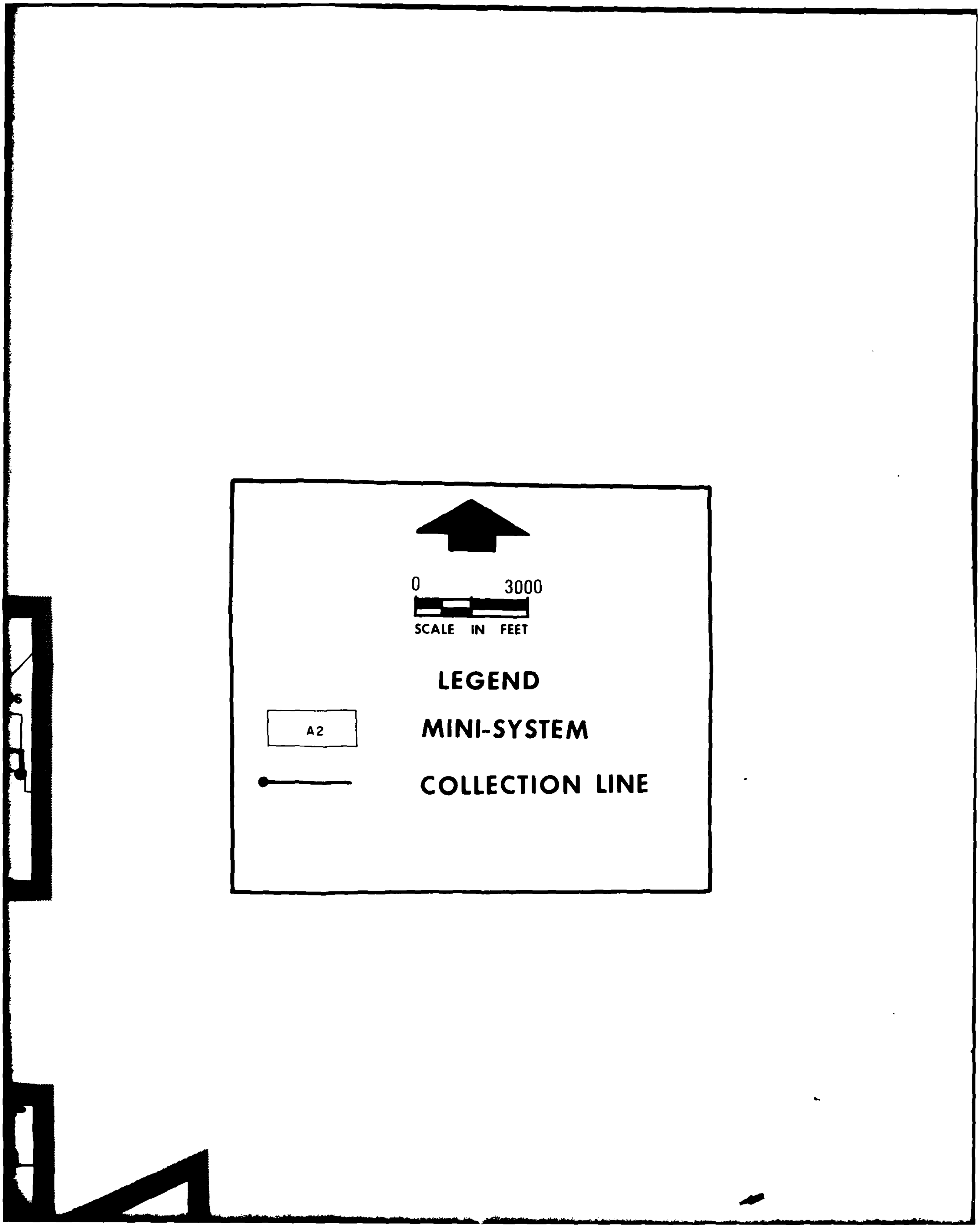
MINI-SYSTEM
COLLECTION LINE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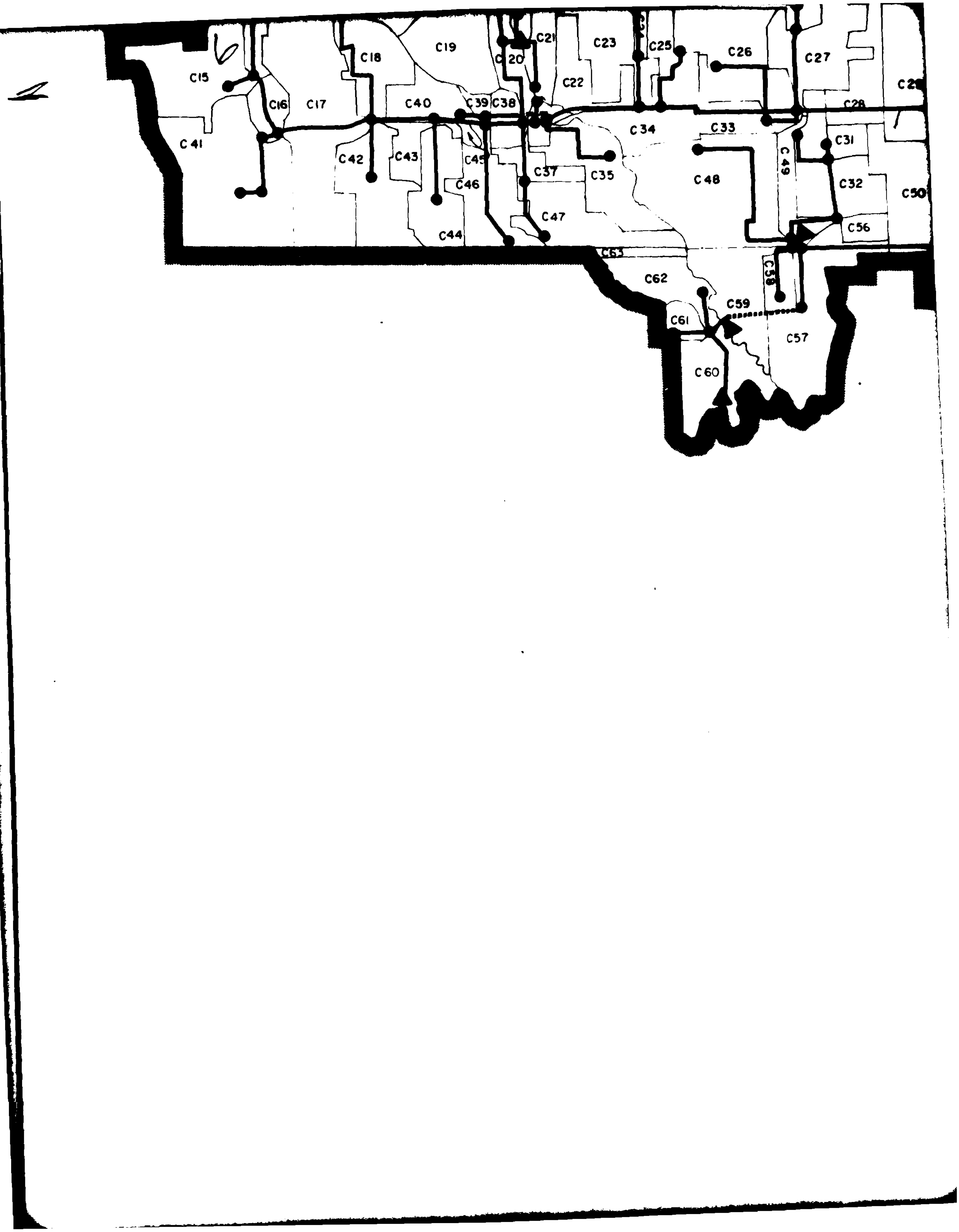
MINI-SYSTEM
COLLECTION LINE



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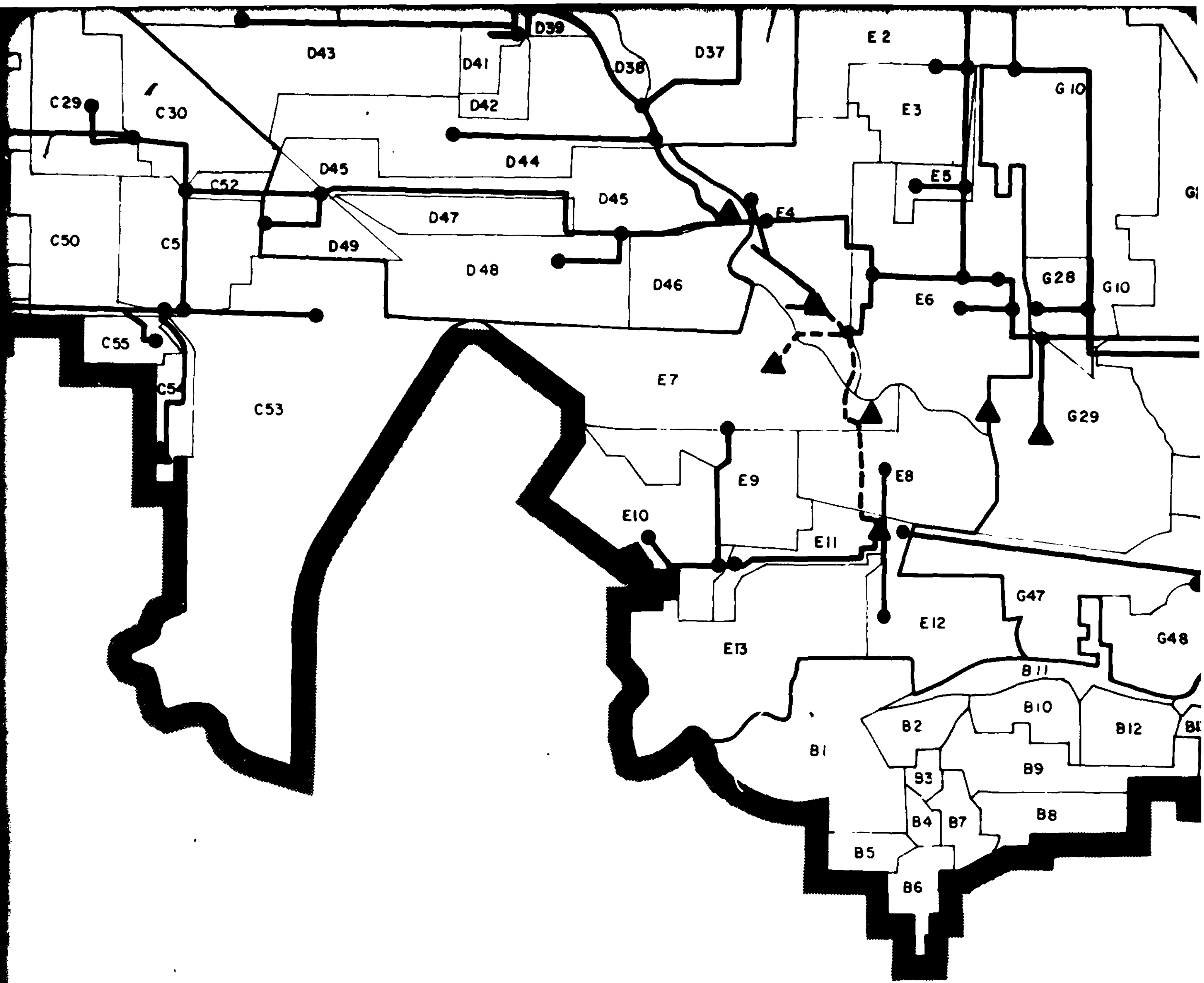

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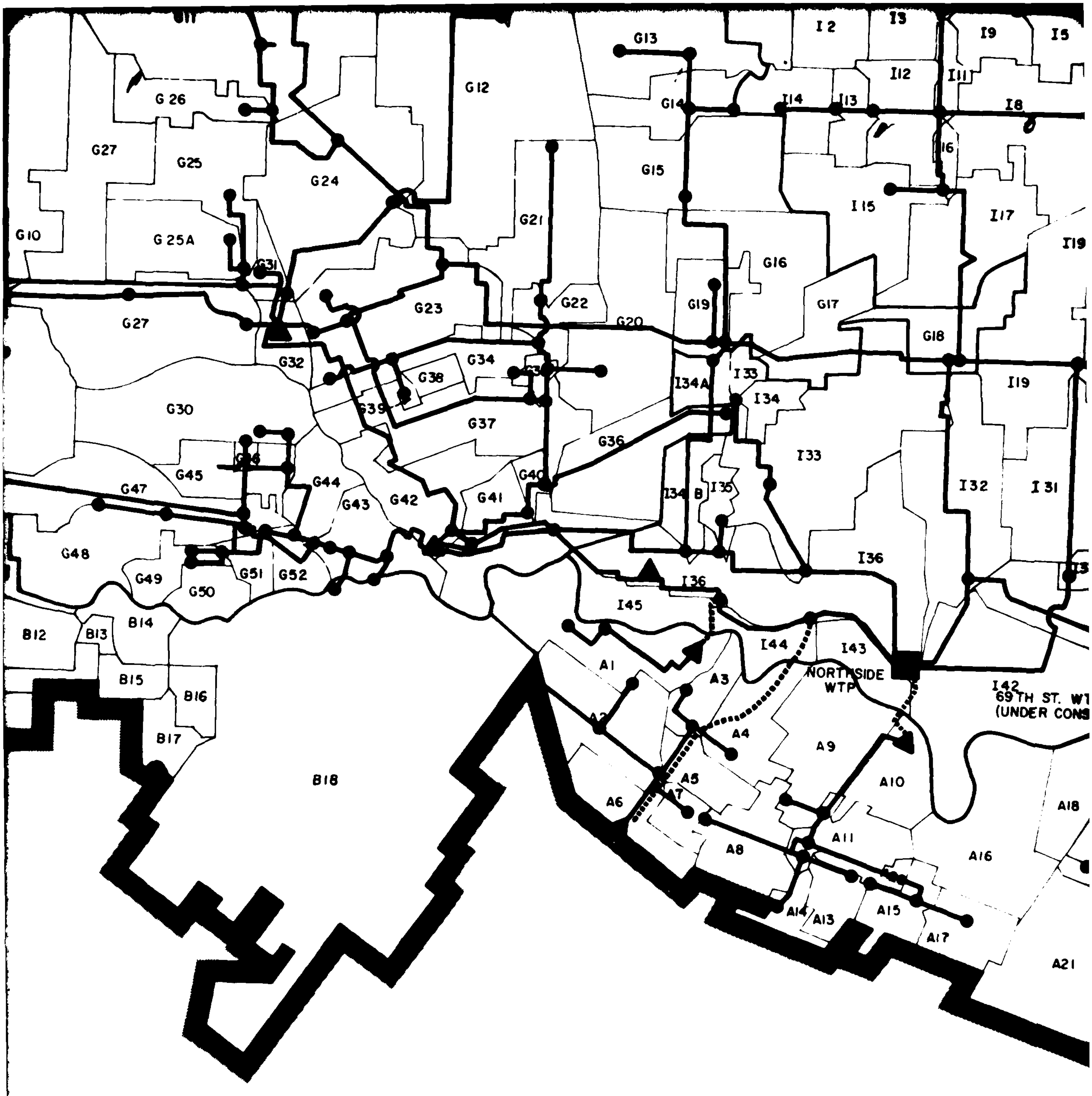

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G10
G 25A
G21
I19
G31
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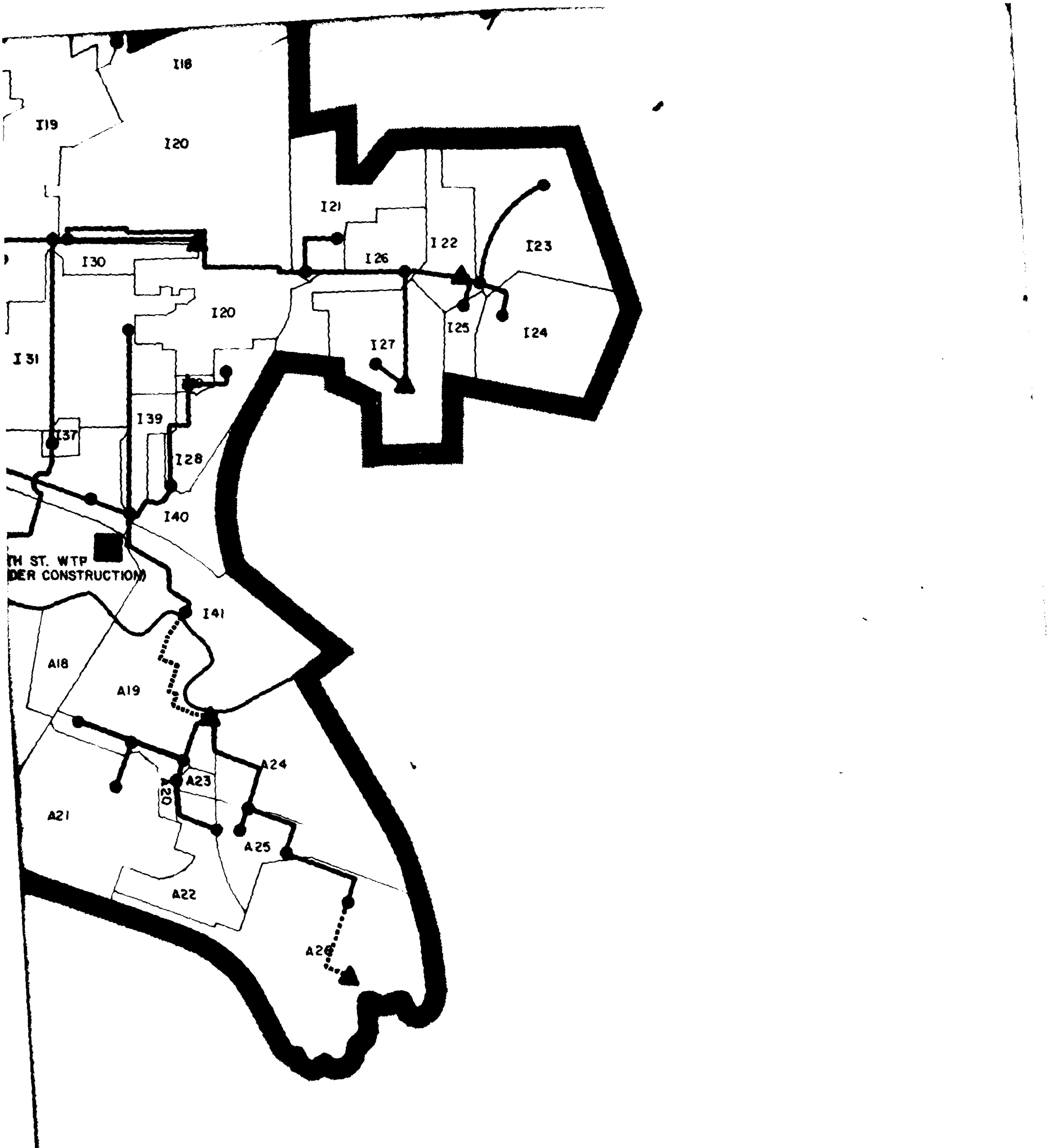

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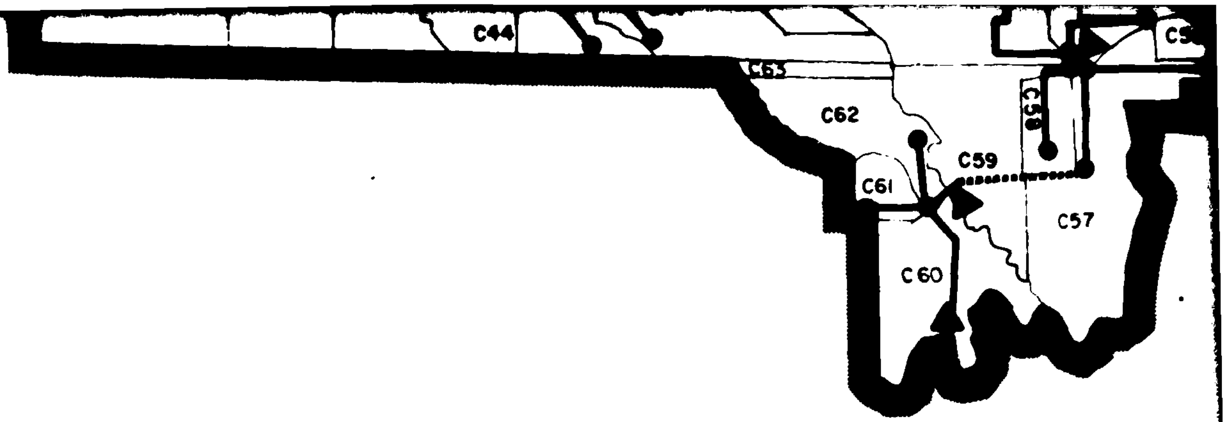

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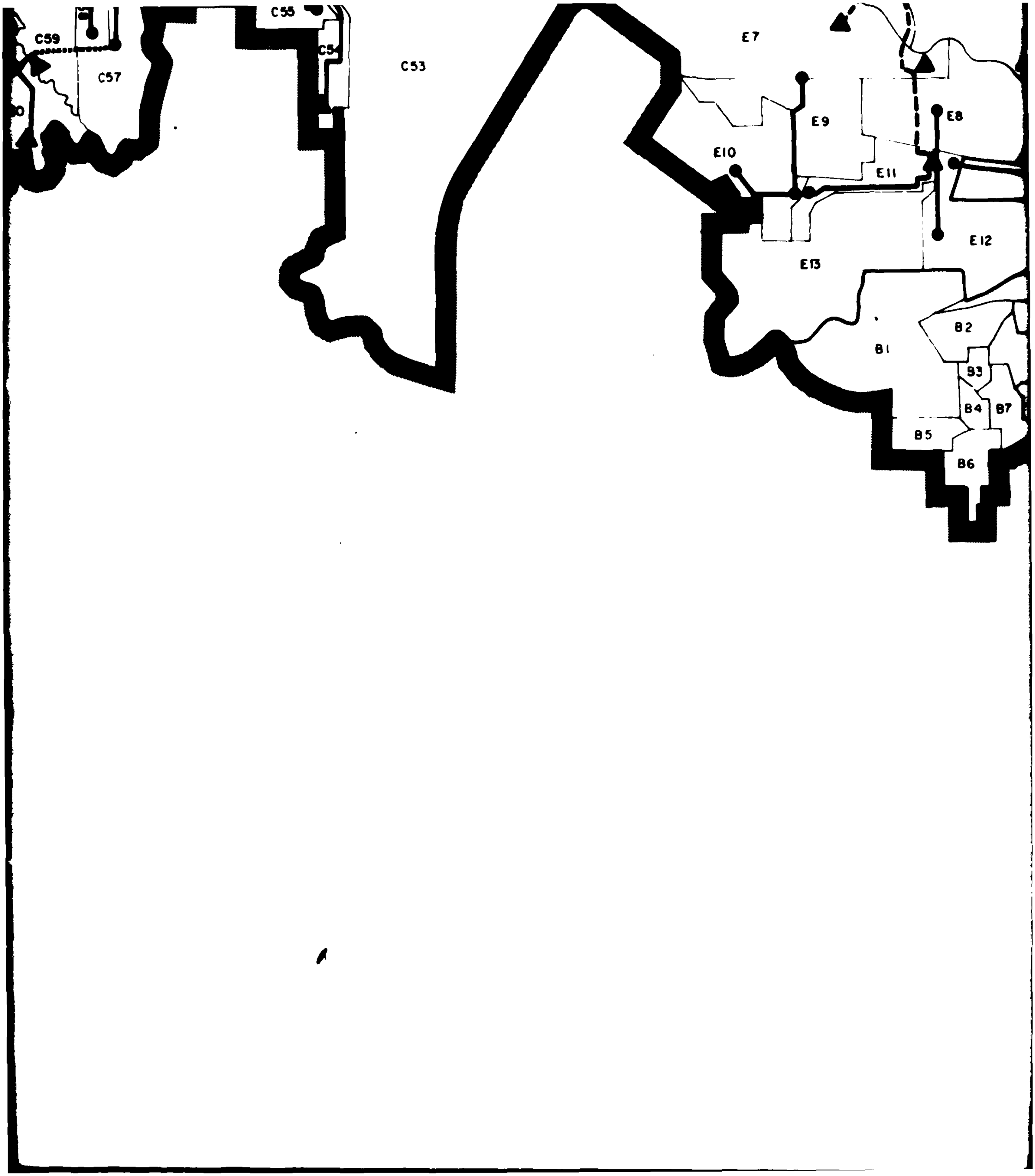
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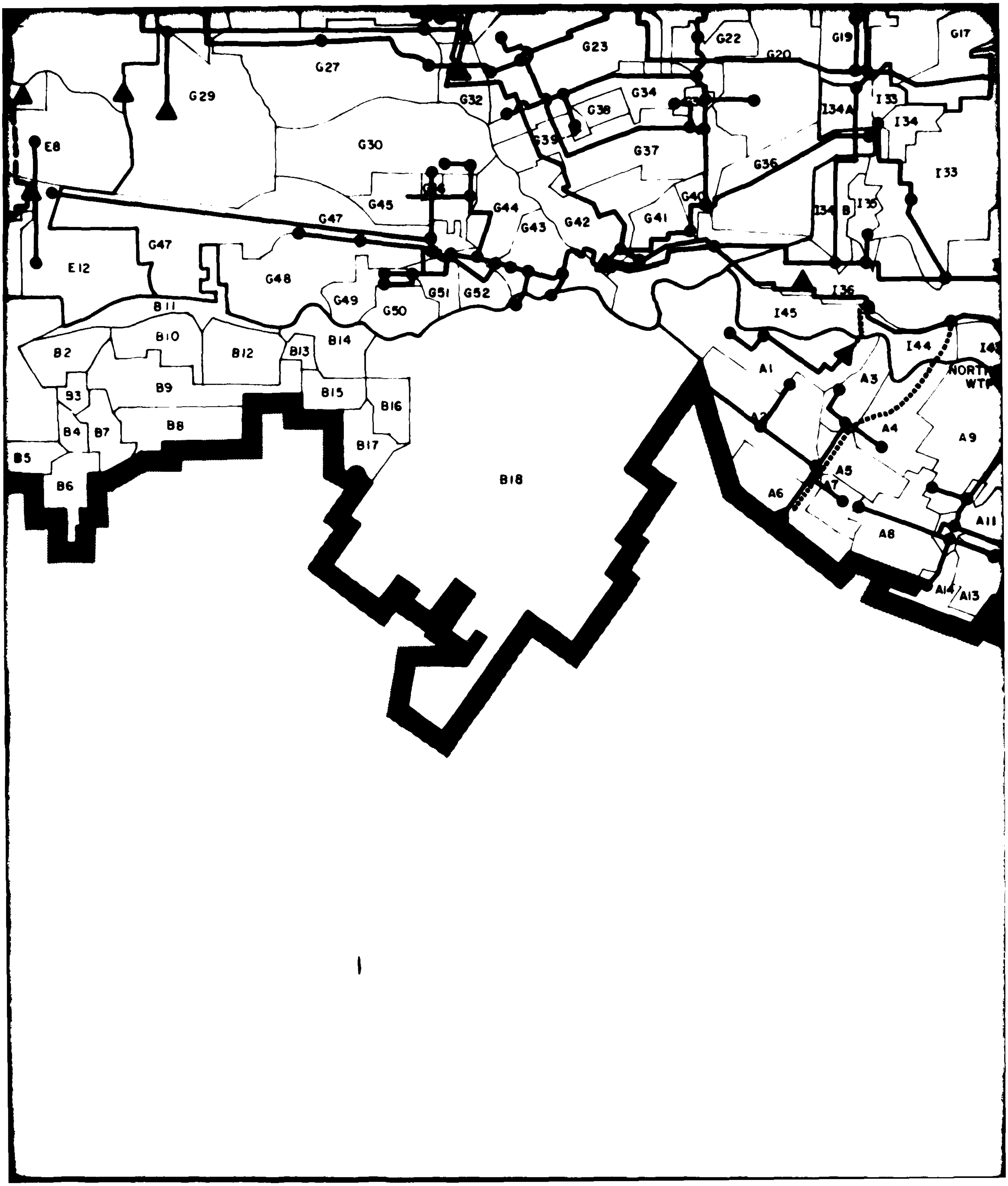
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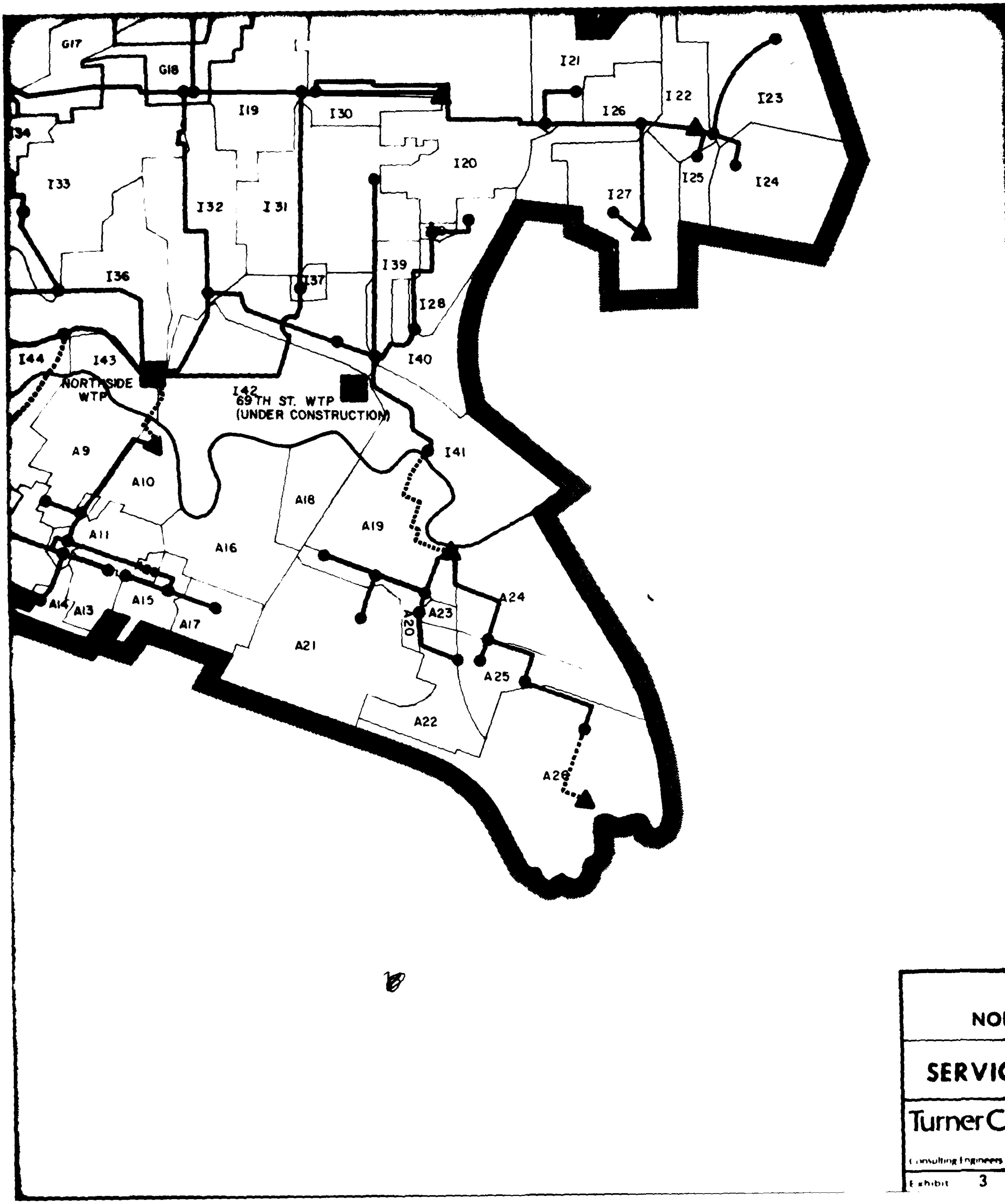

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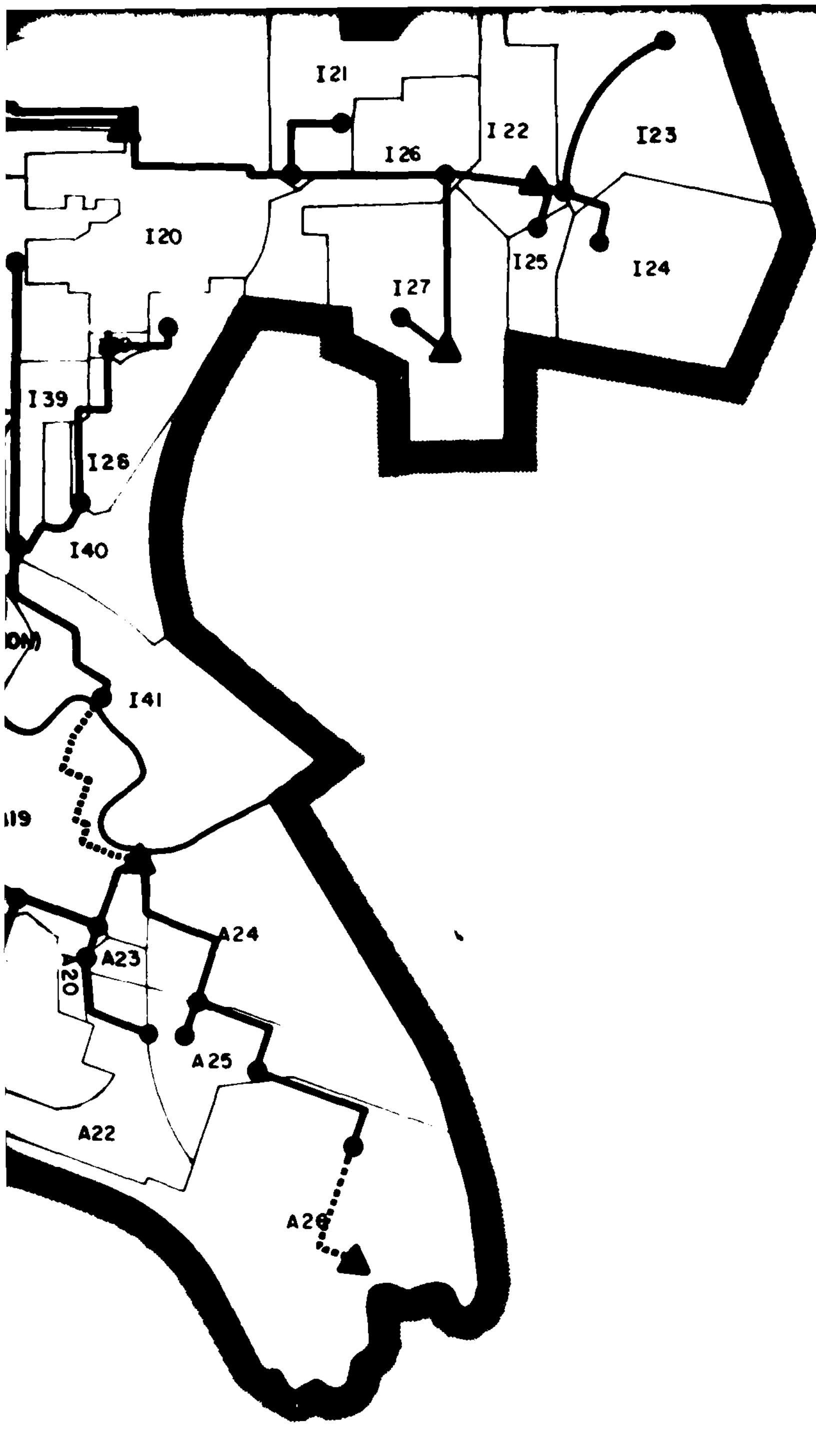
Exhibit 3



CITY OF HOUSTON
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SERVICE AREA MINISYSTEMS

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Consulting Engineers

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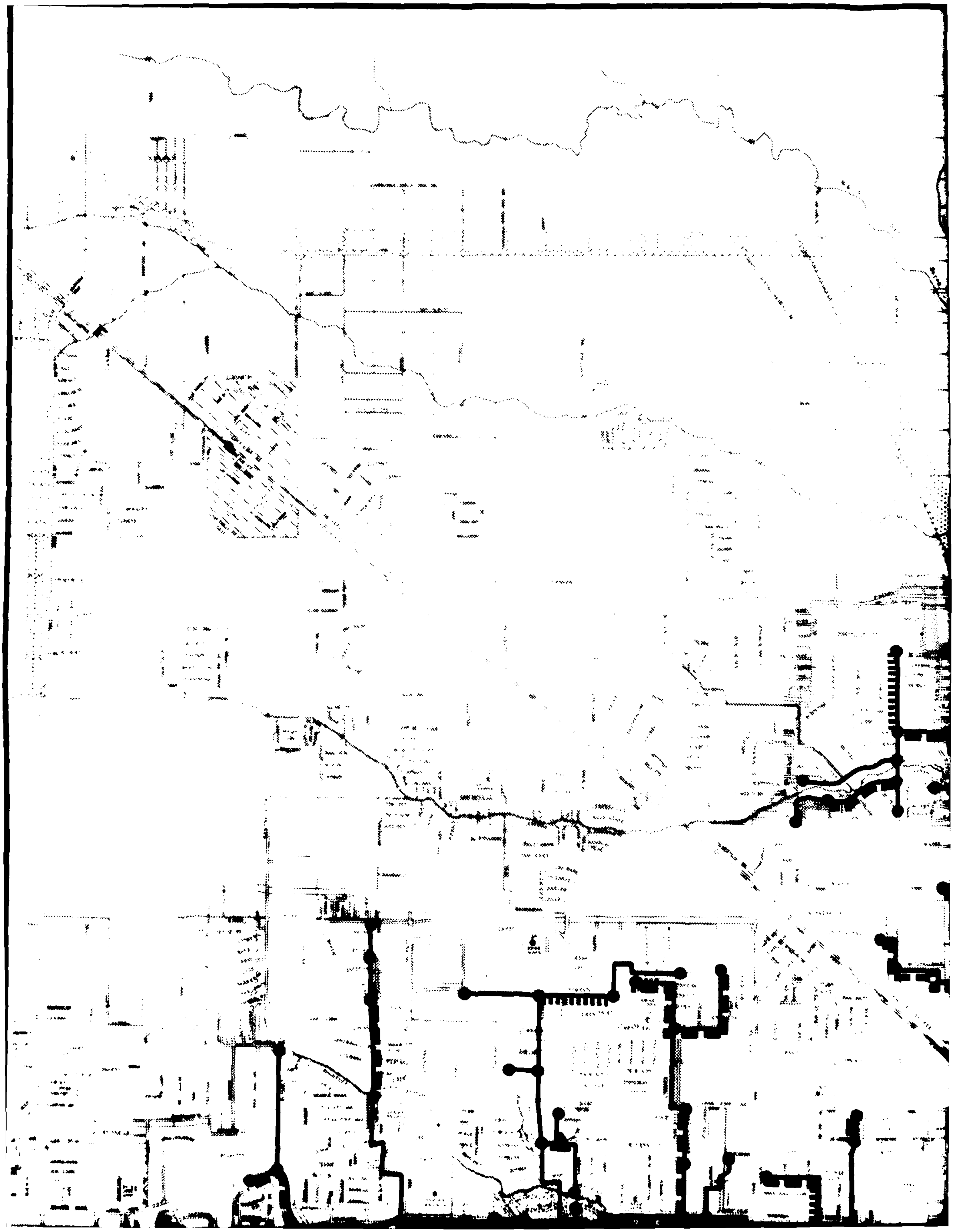
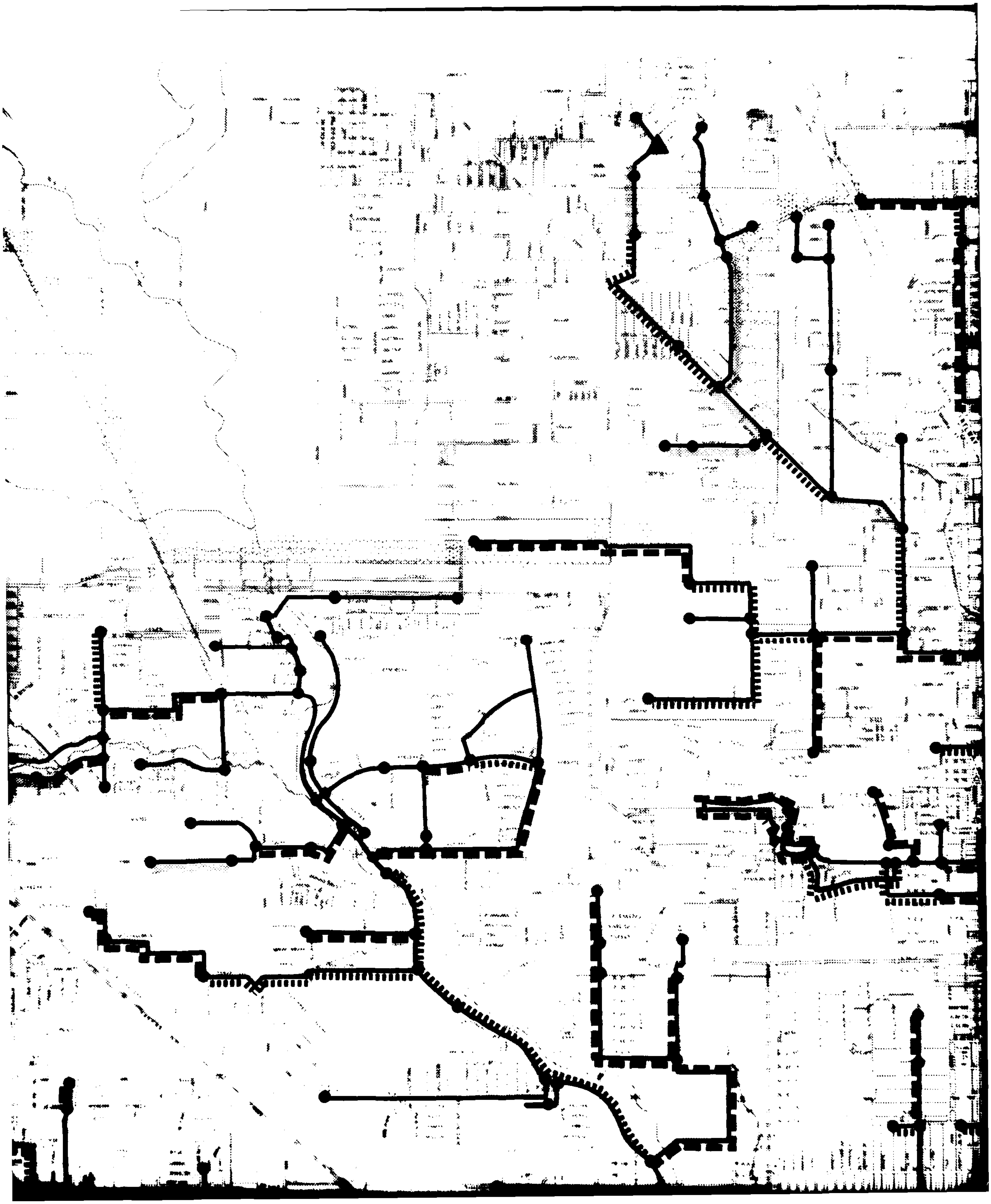
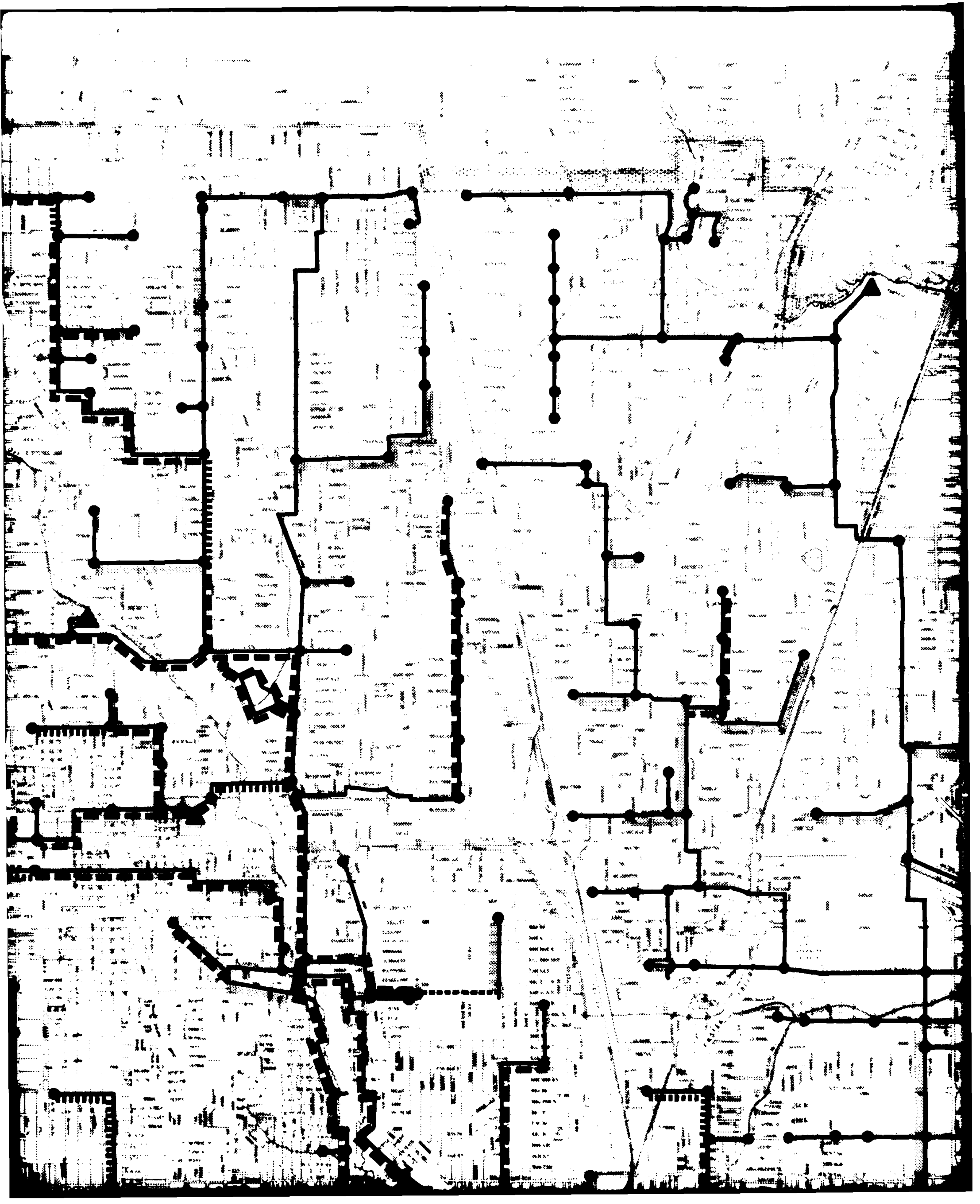
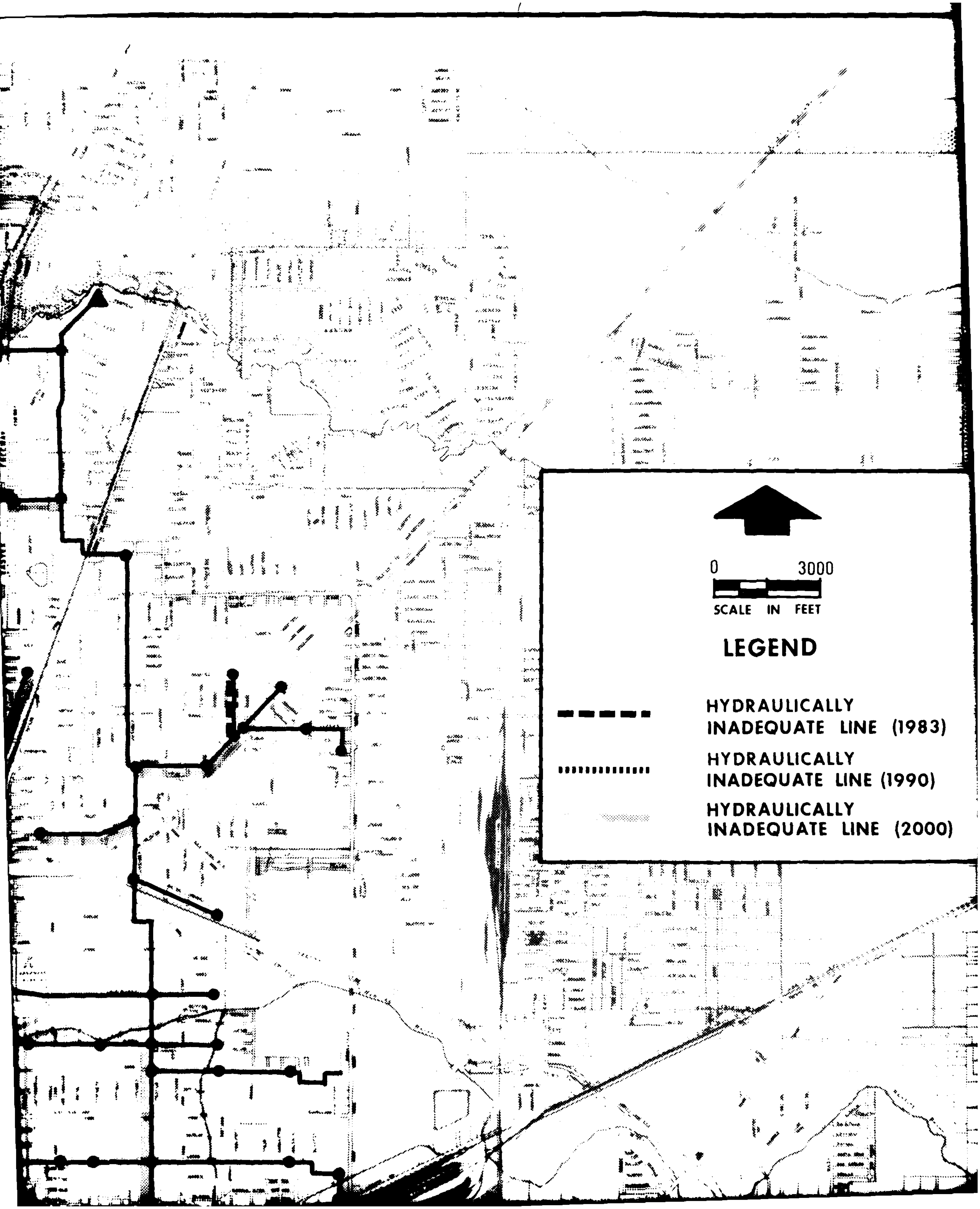
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 3 | Job No. 2356-010 | Date JULY 1979





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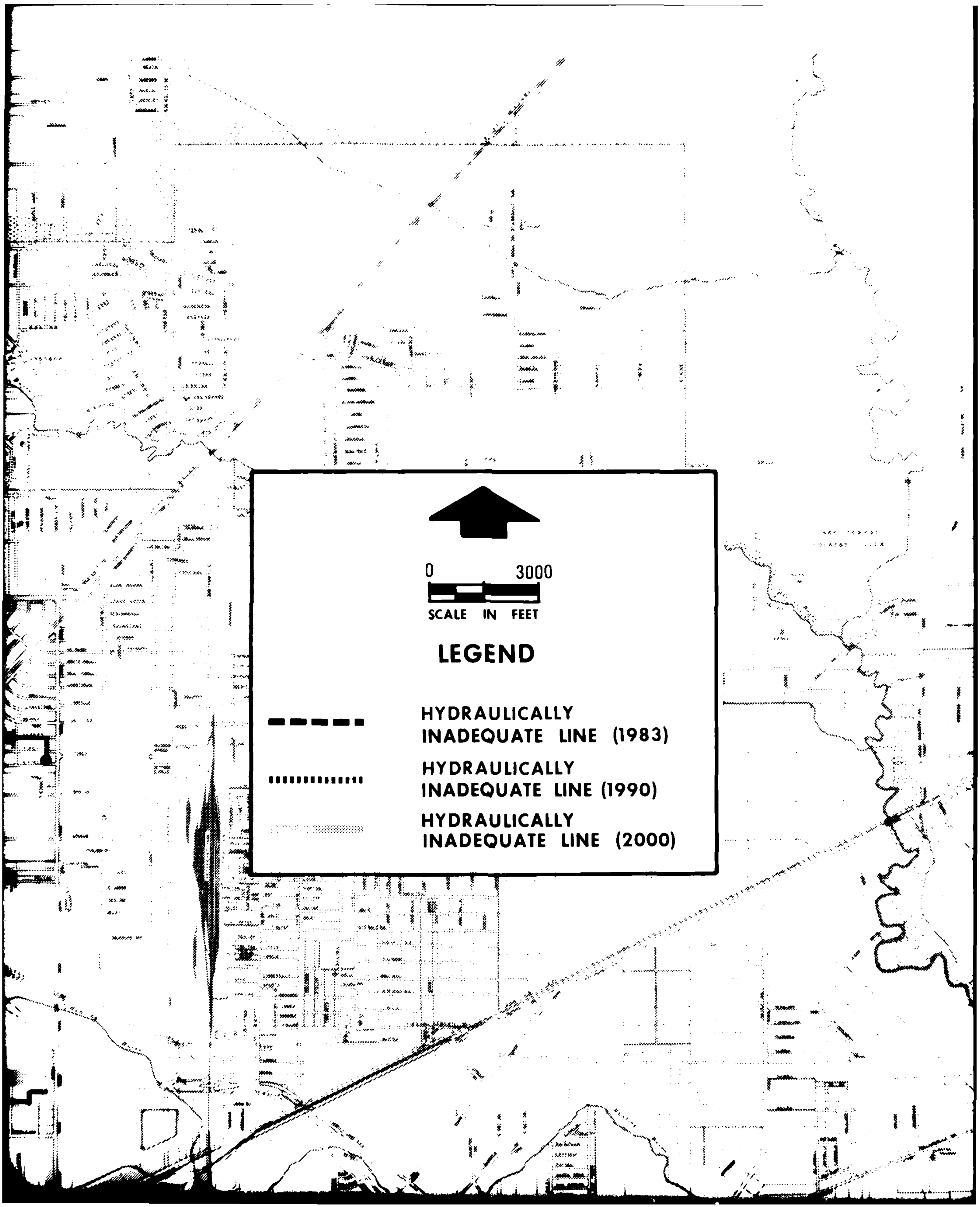
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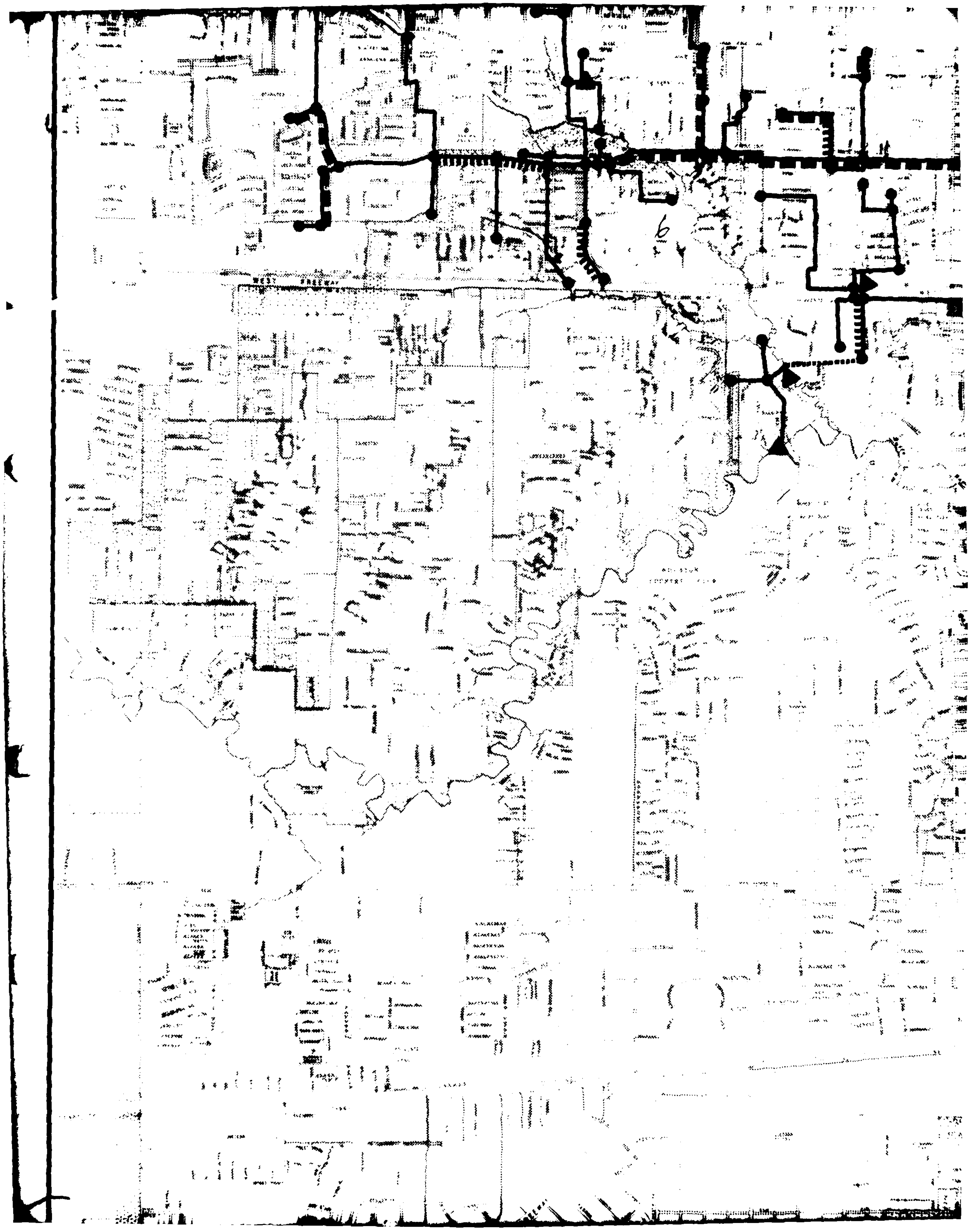
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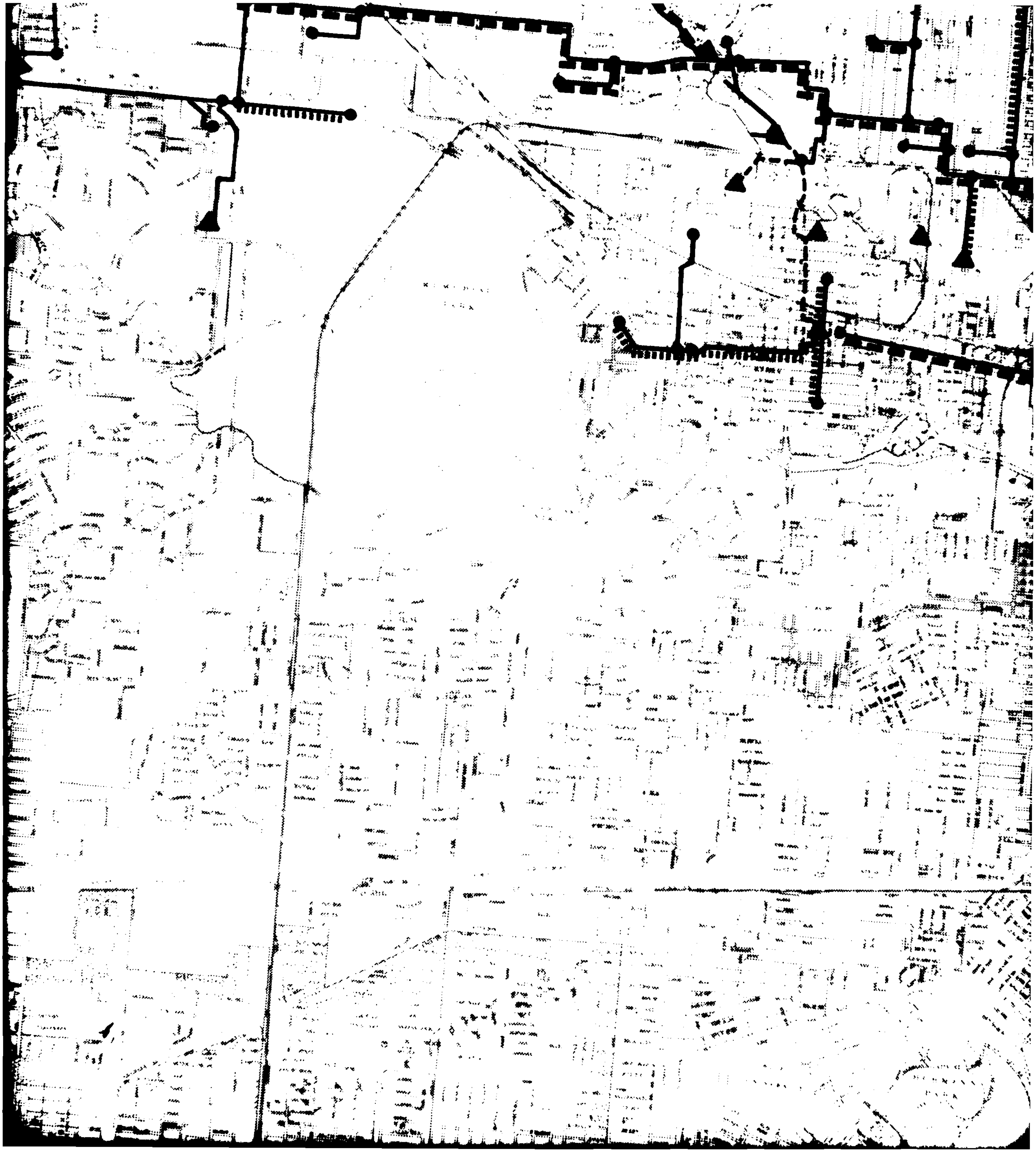

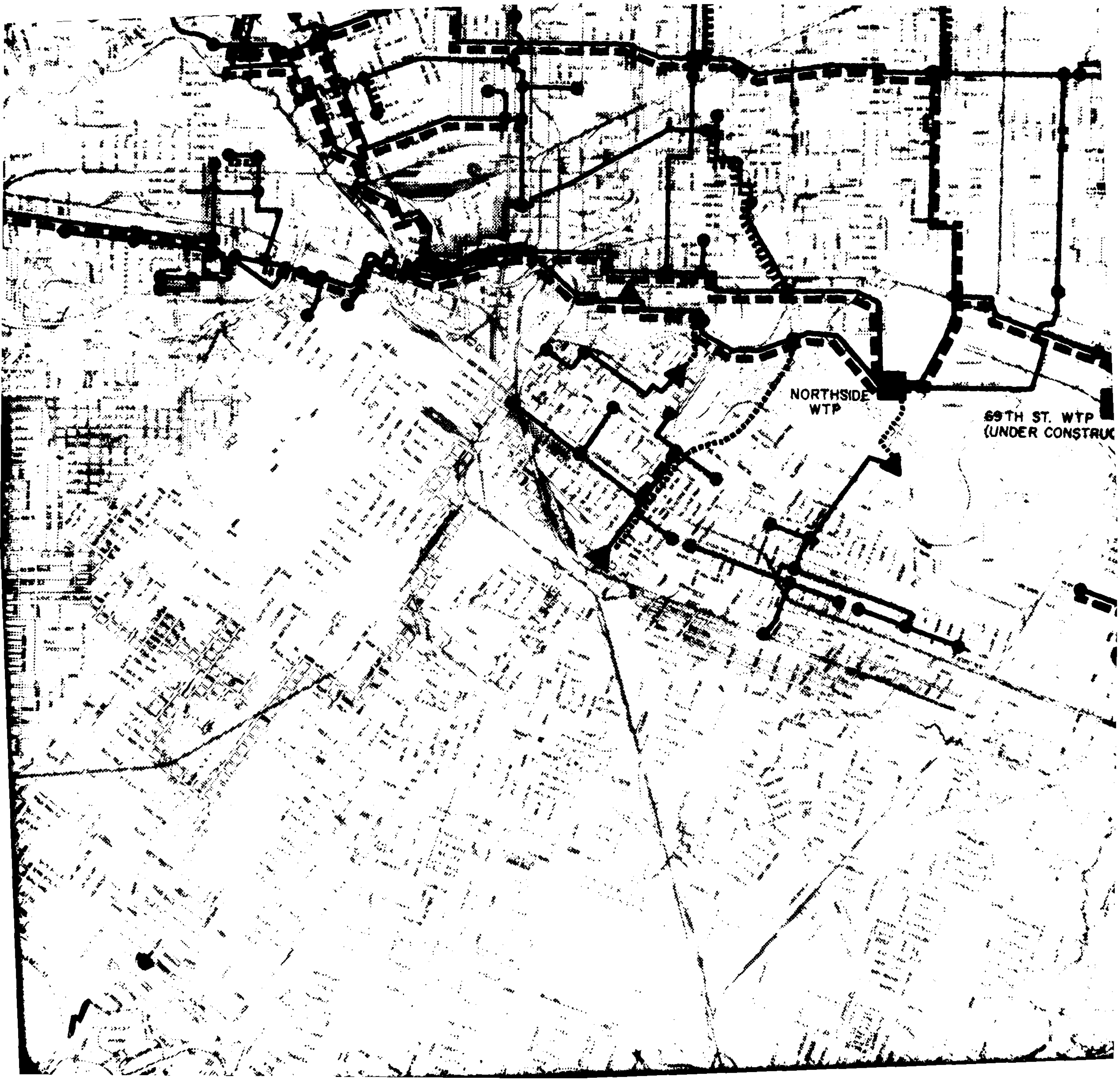

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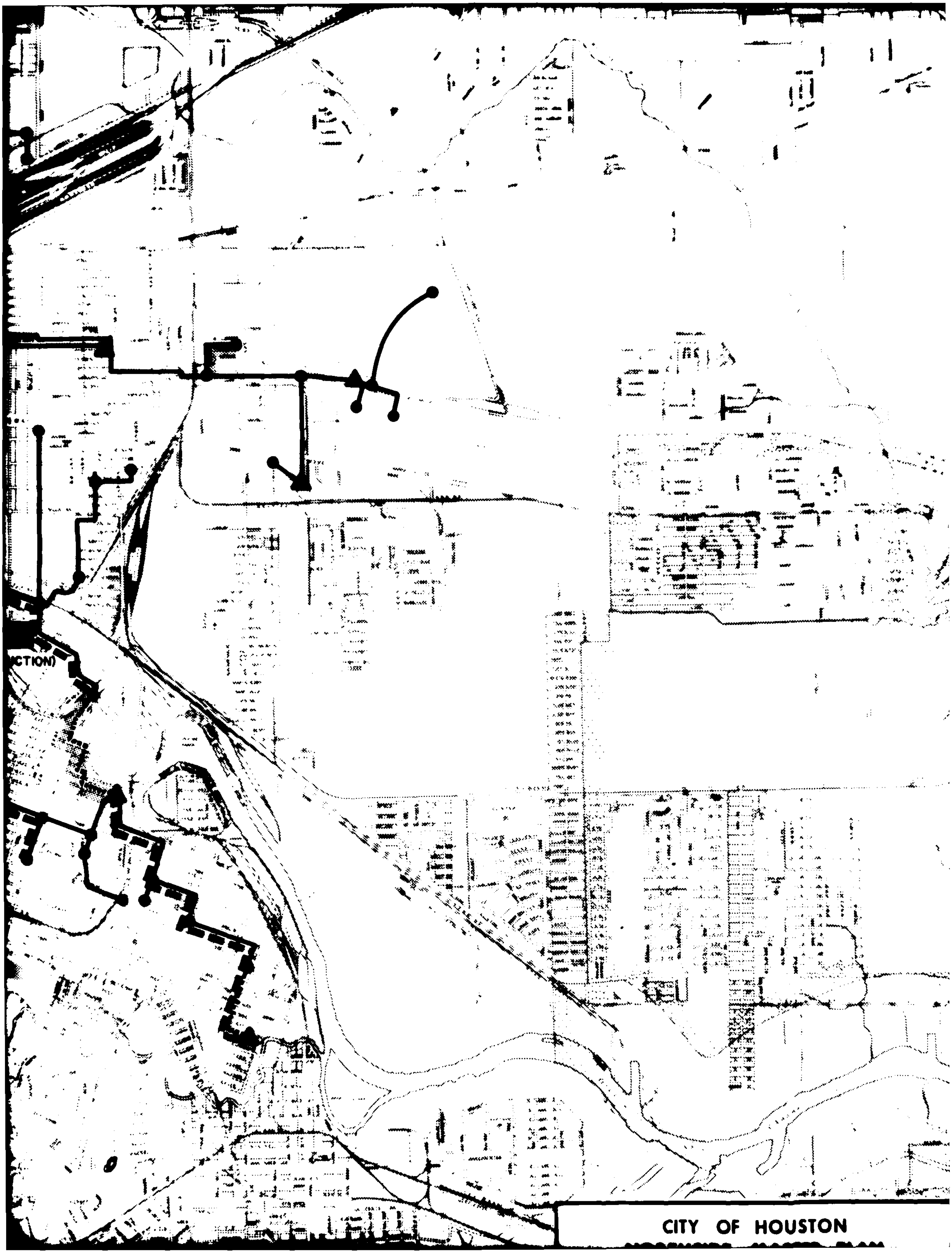
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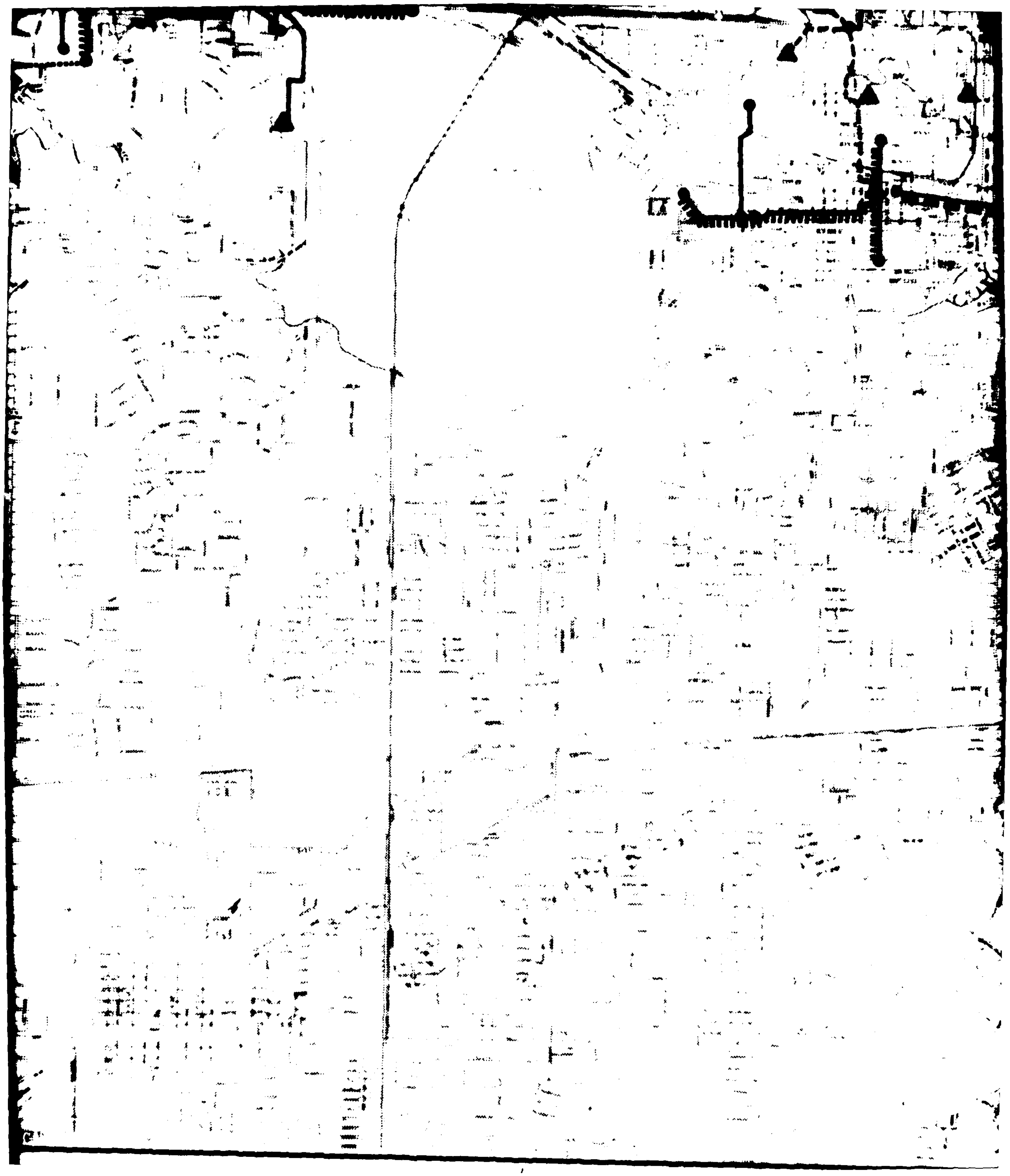


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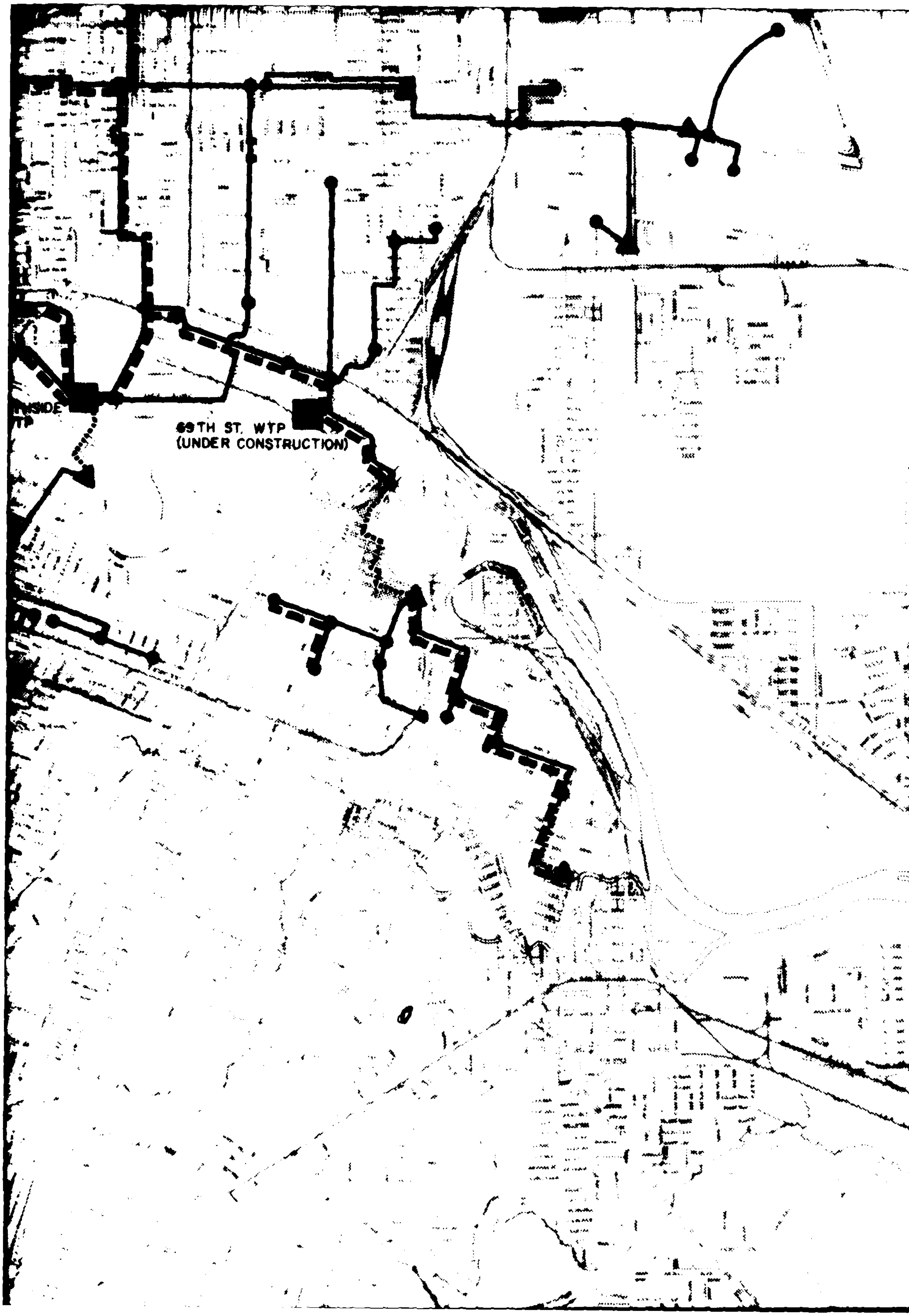

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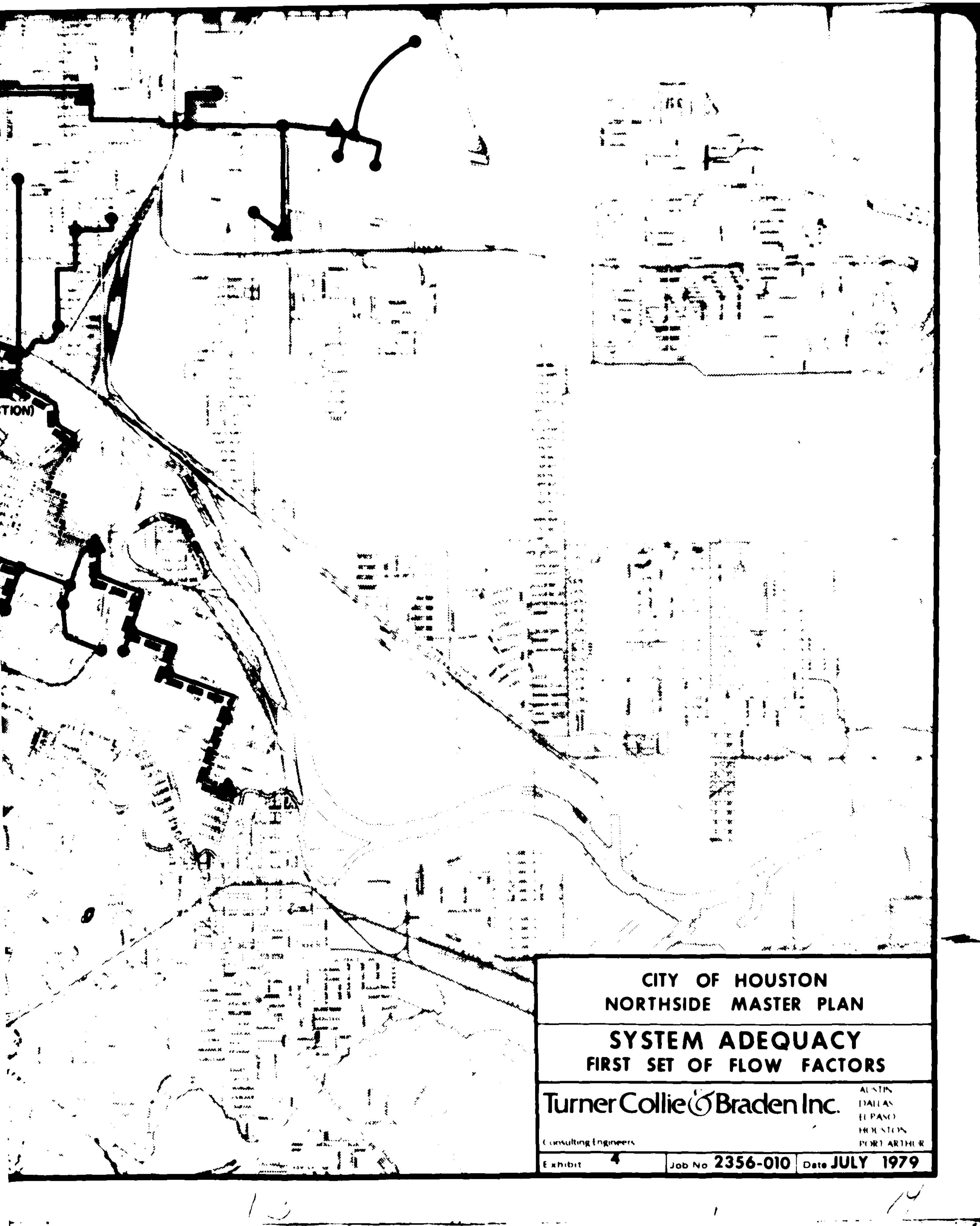
SYSTEM
FIRST SET OF

Turner Collie &
Consulting Engineers

Exhibit 4 Job No.



CITY OF HOUSTON
NORTHSIDE MASTER PLAN

SYSTEM ADEQUACY
FIRST SET OF FLOW FACTORS

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Consulting Engineers
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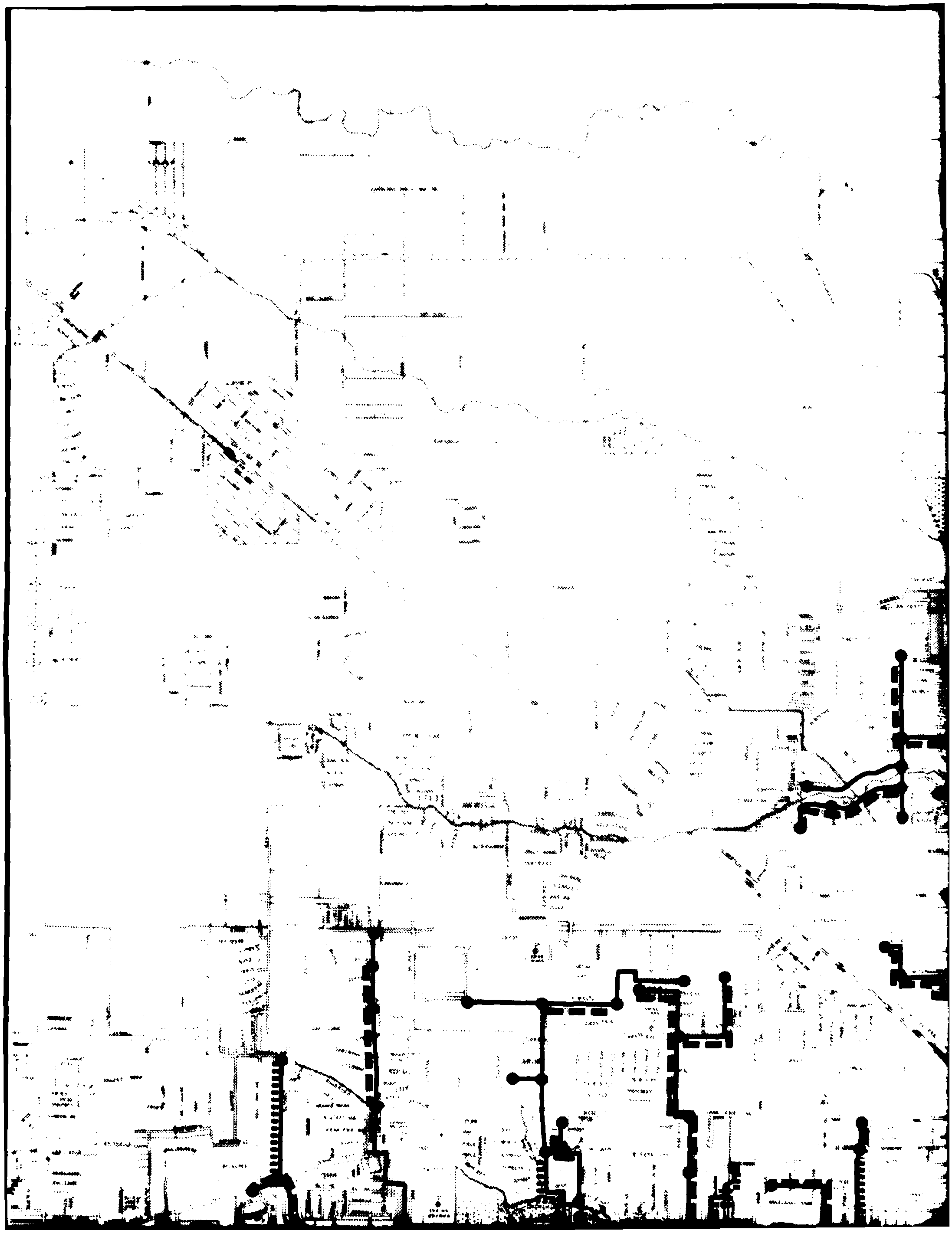
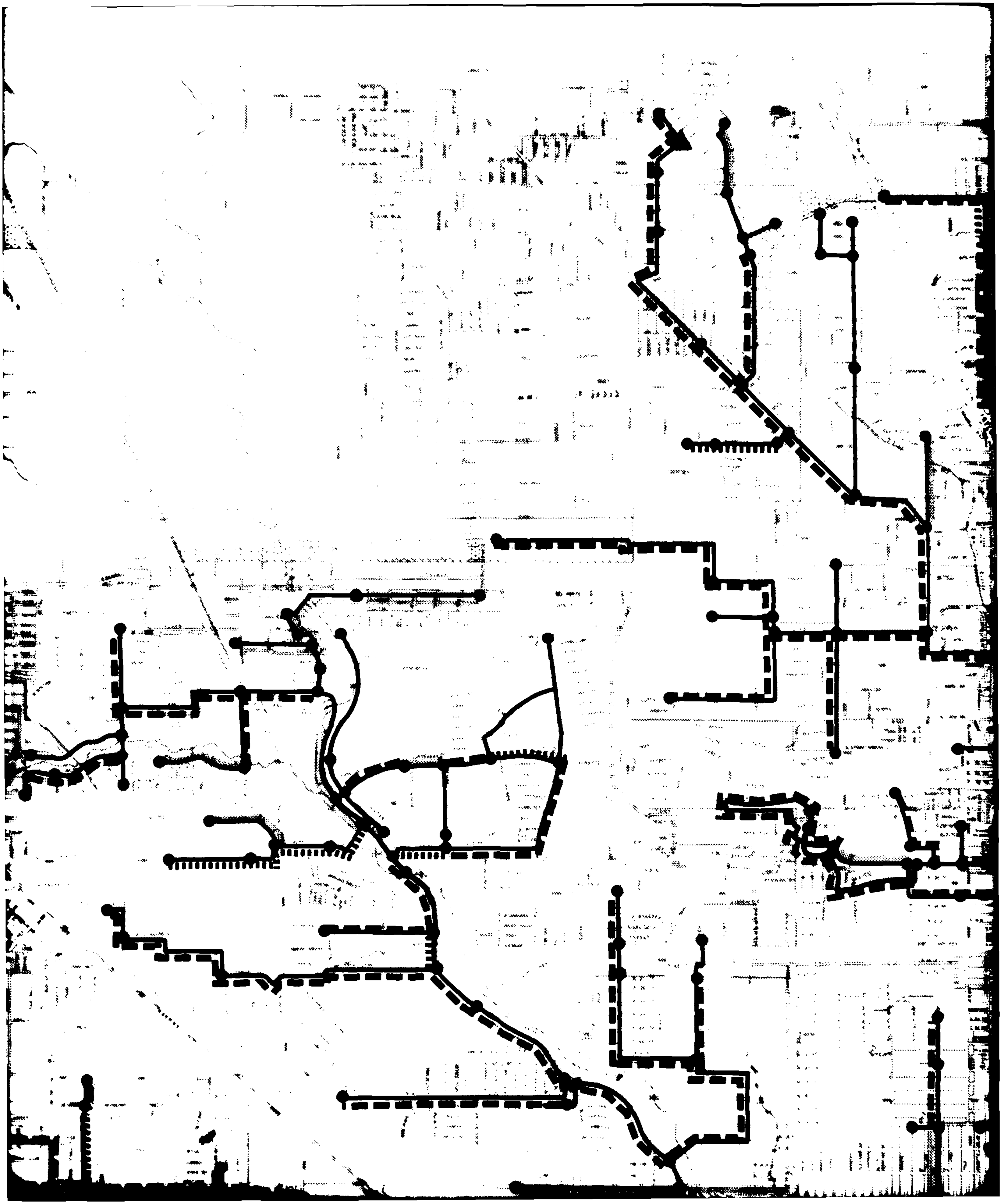
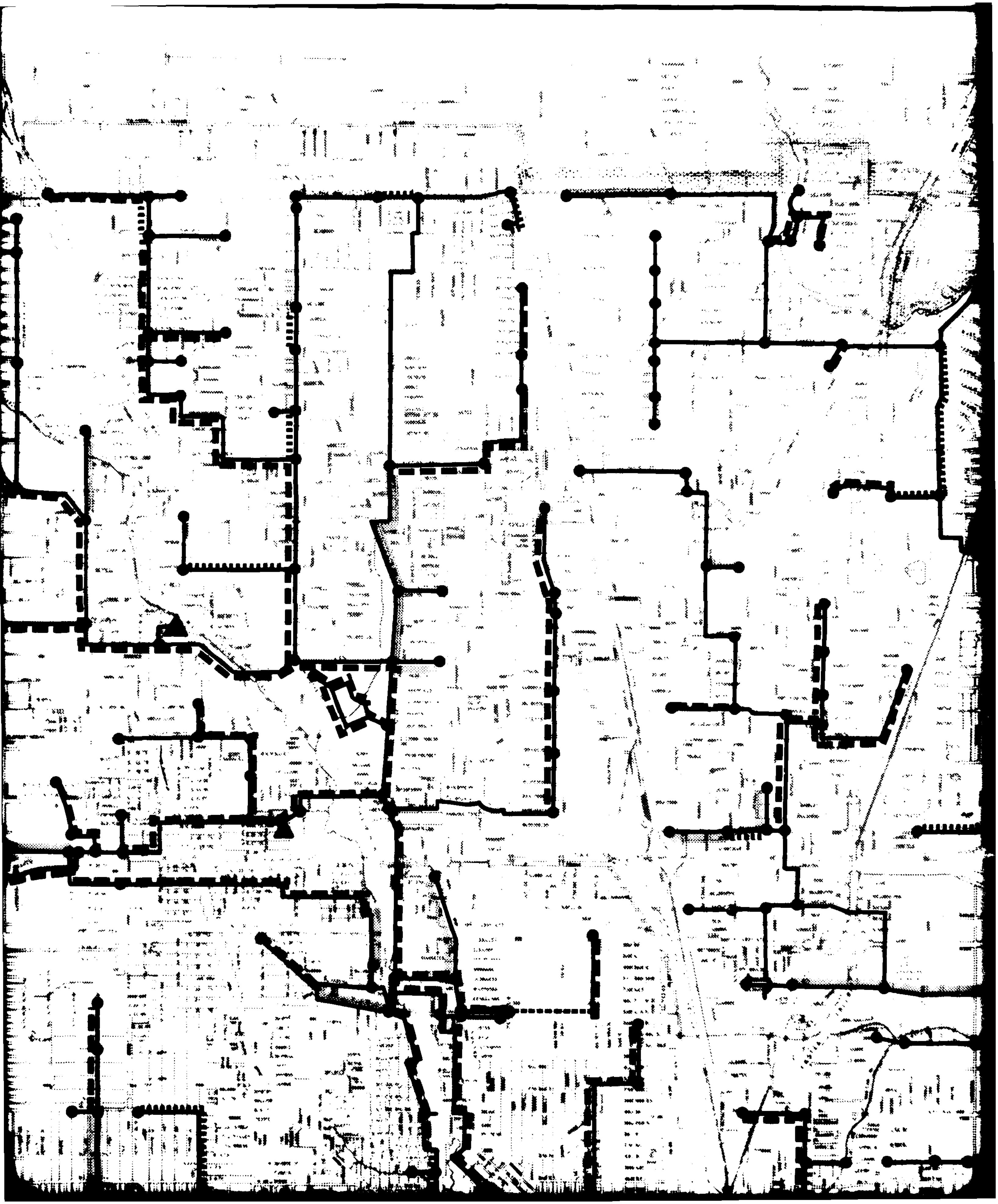
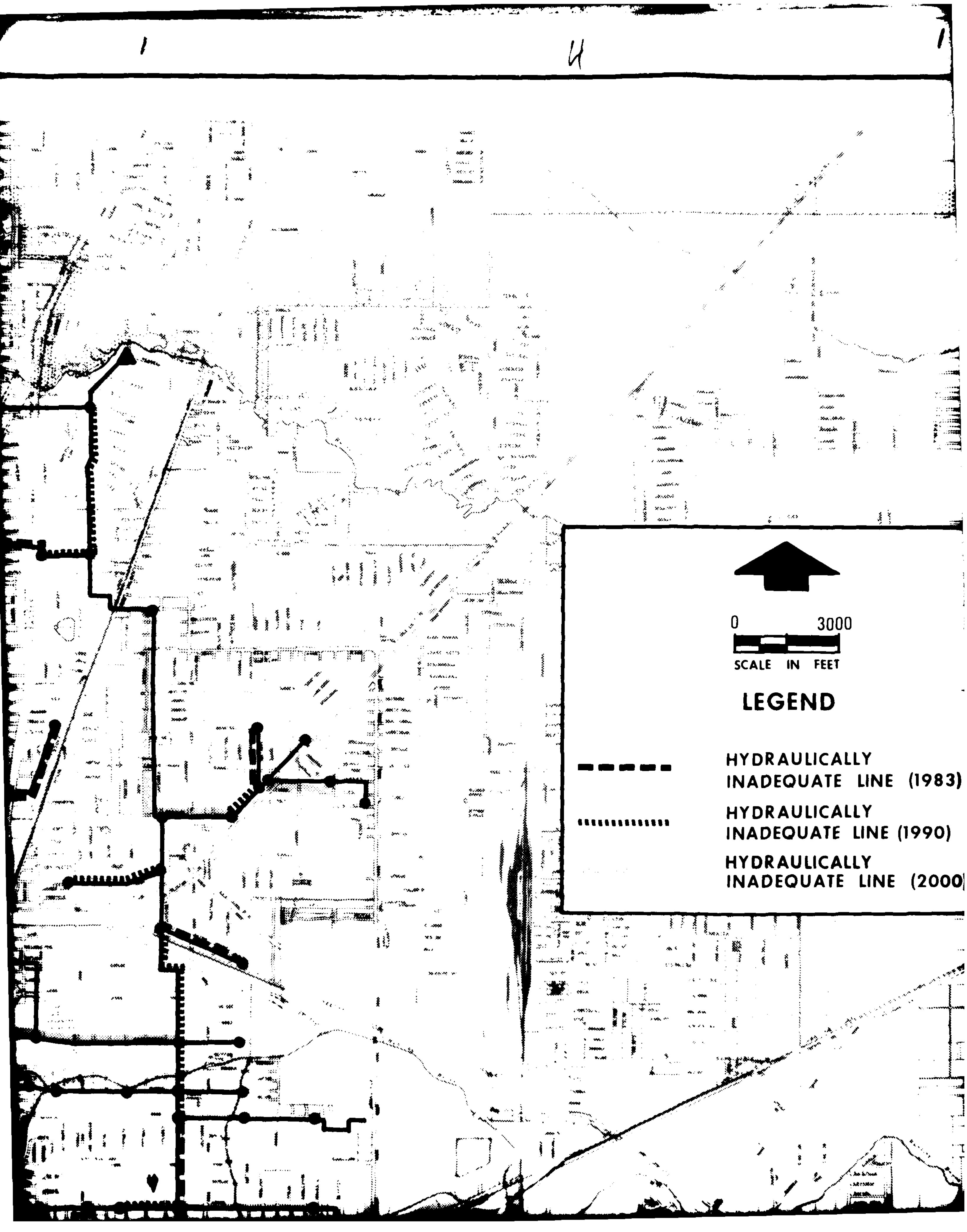
DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 4 | Job No 2356-010 | Date JULY 1979









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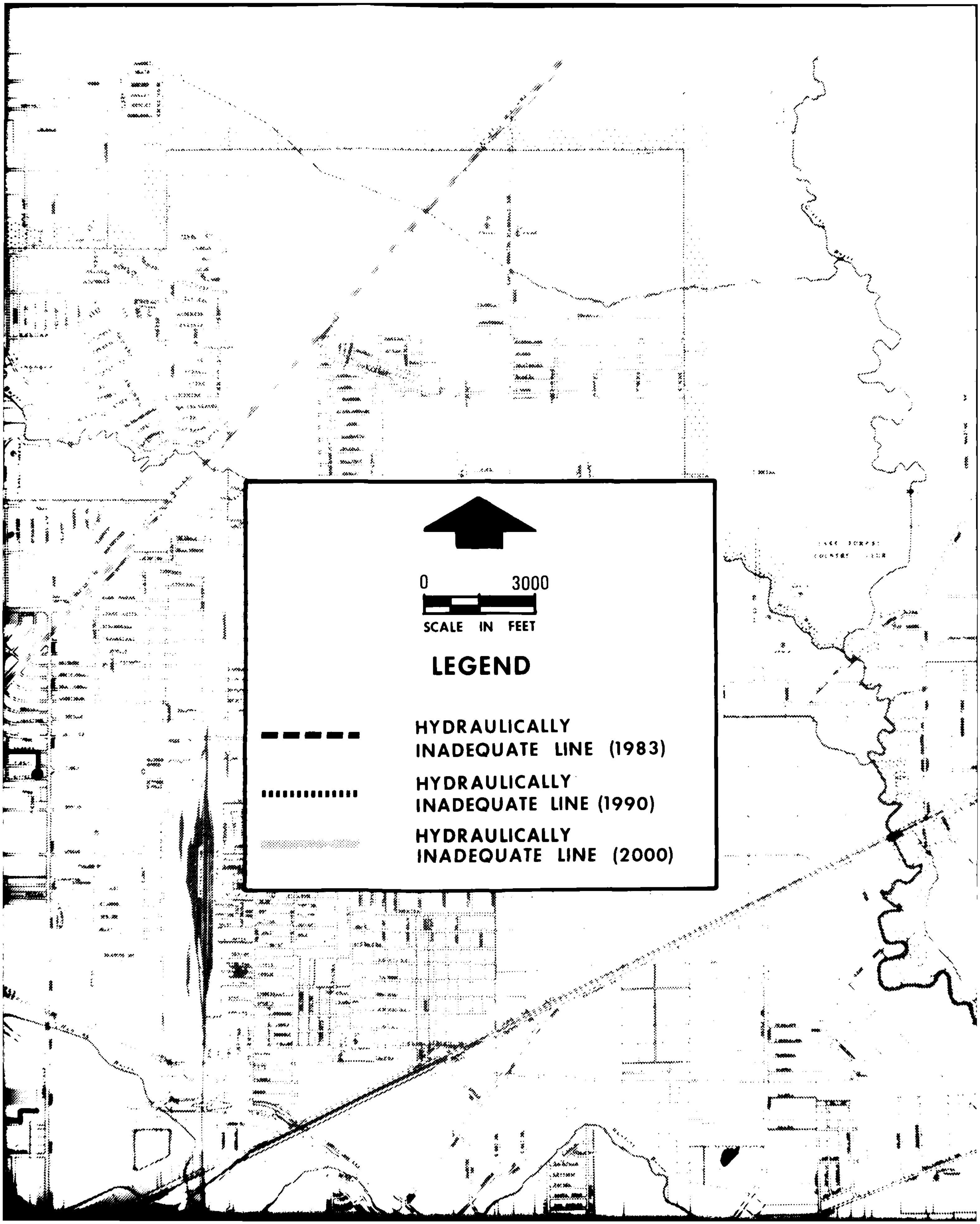
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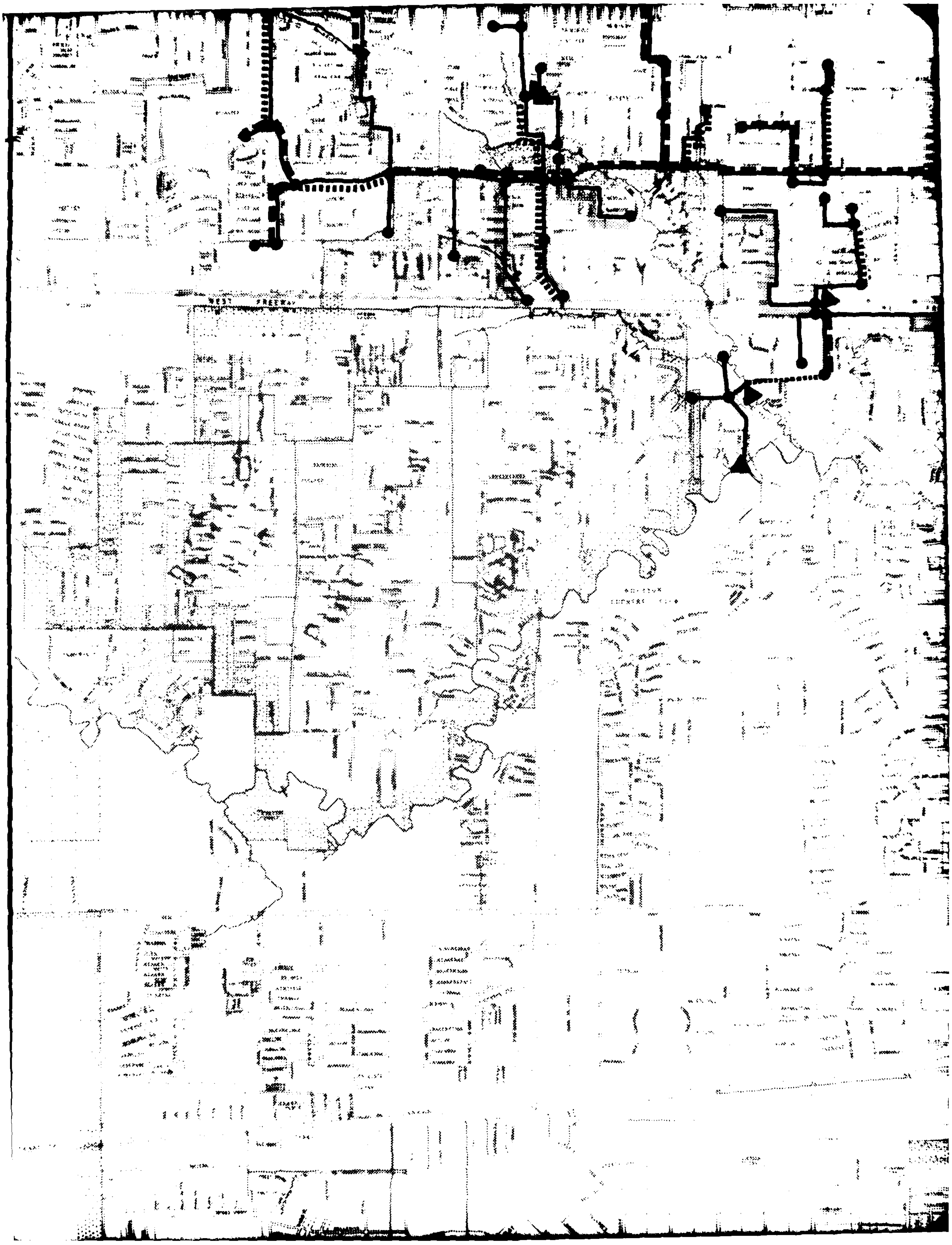
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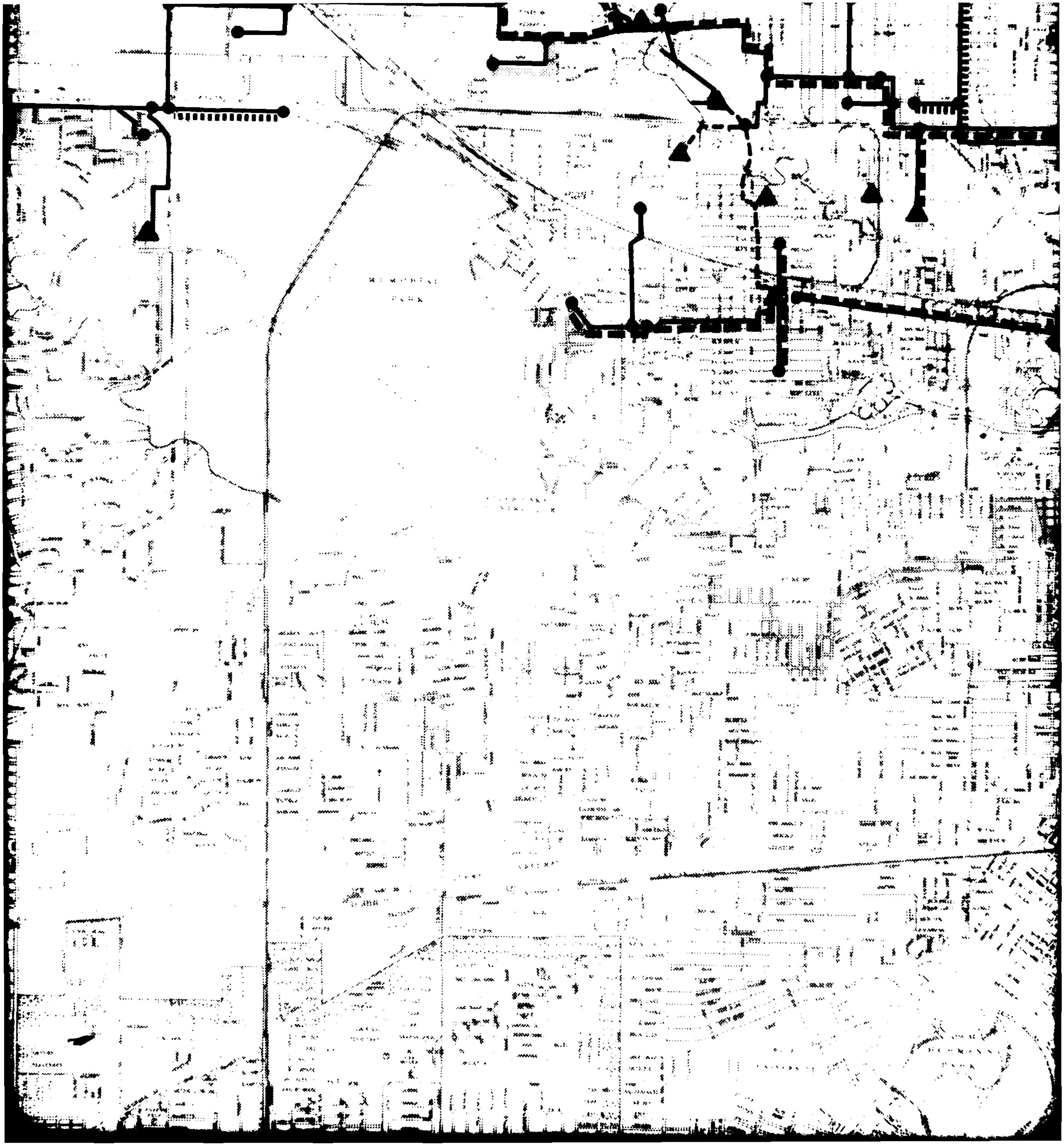

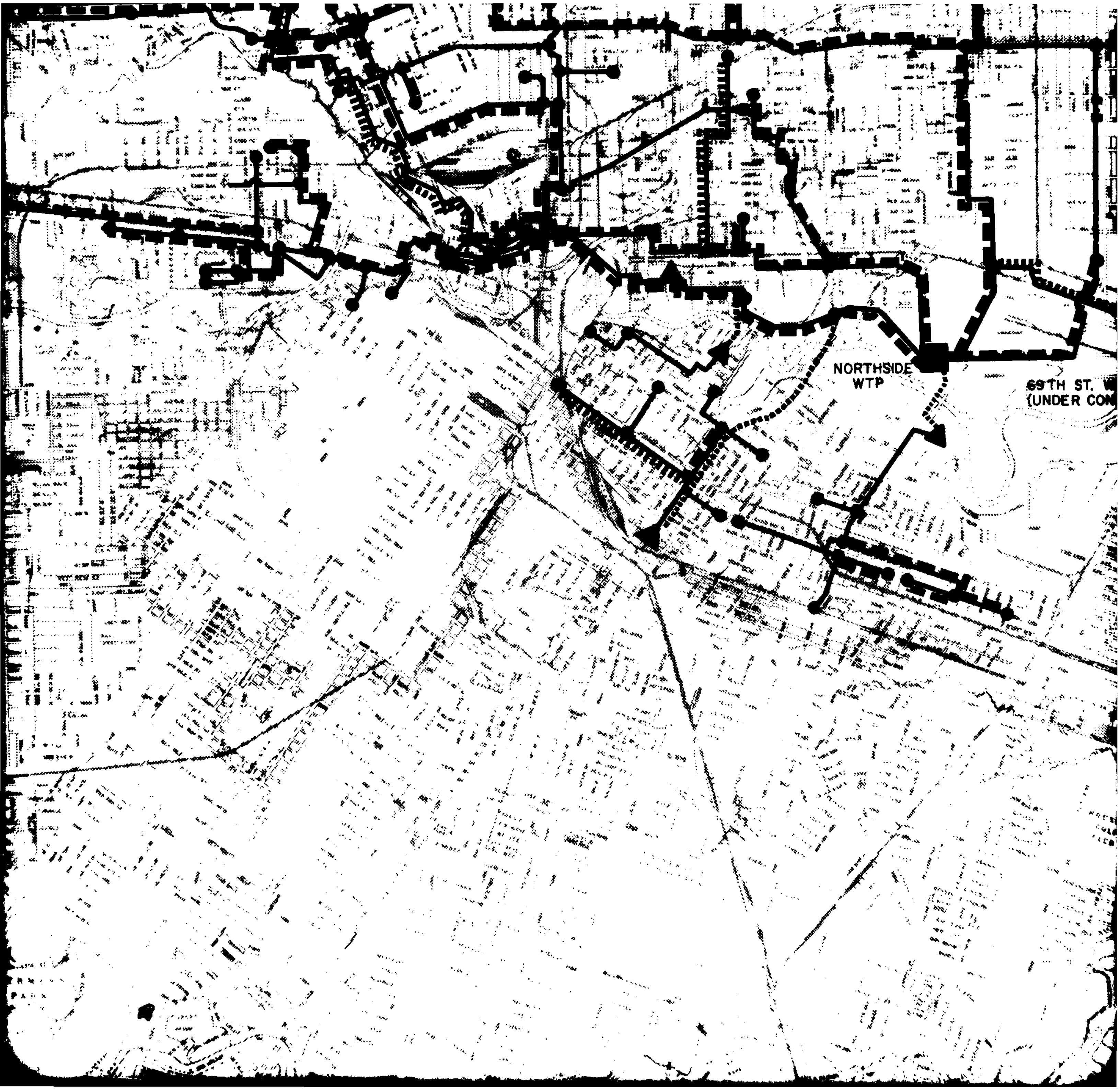

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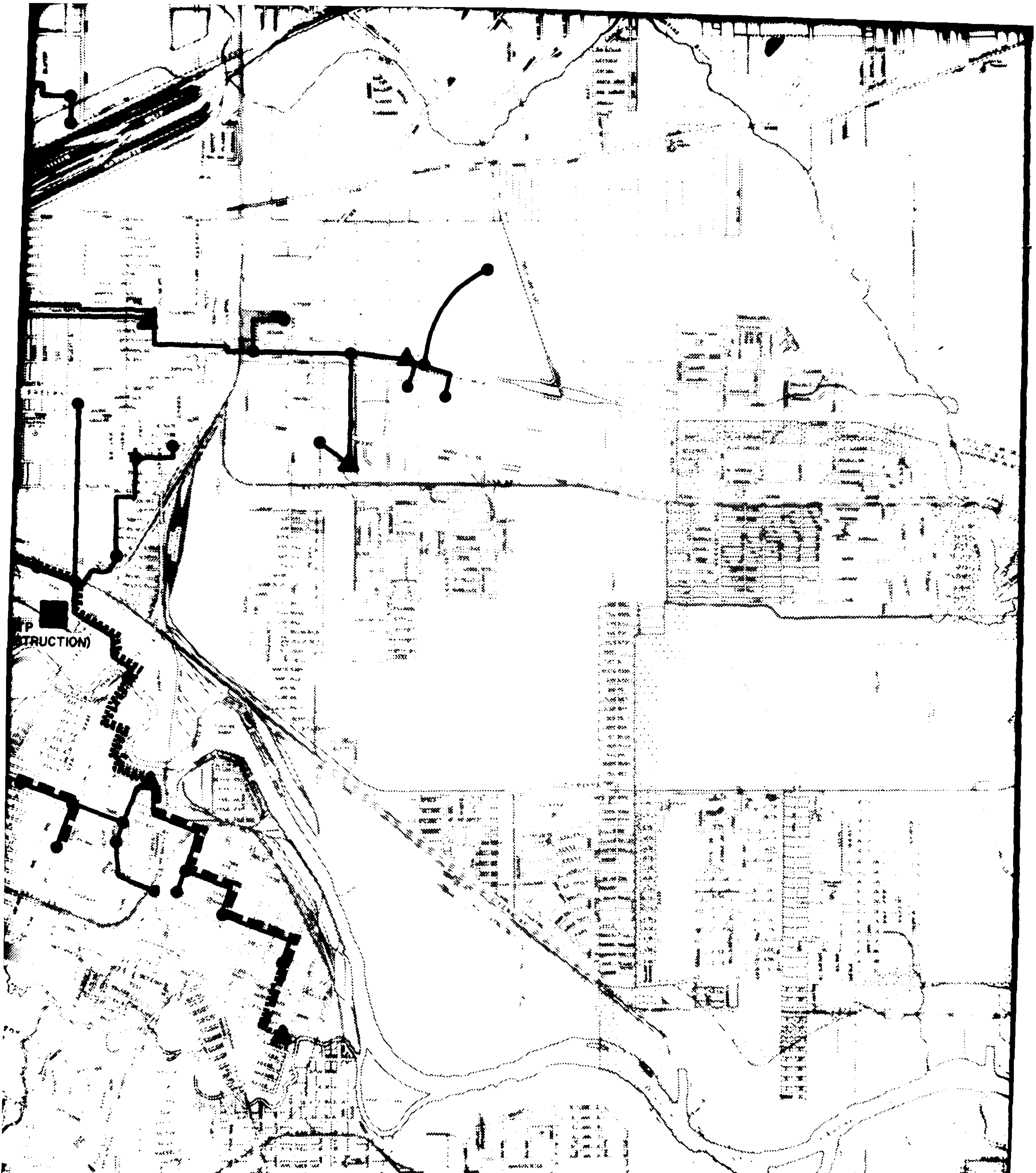
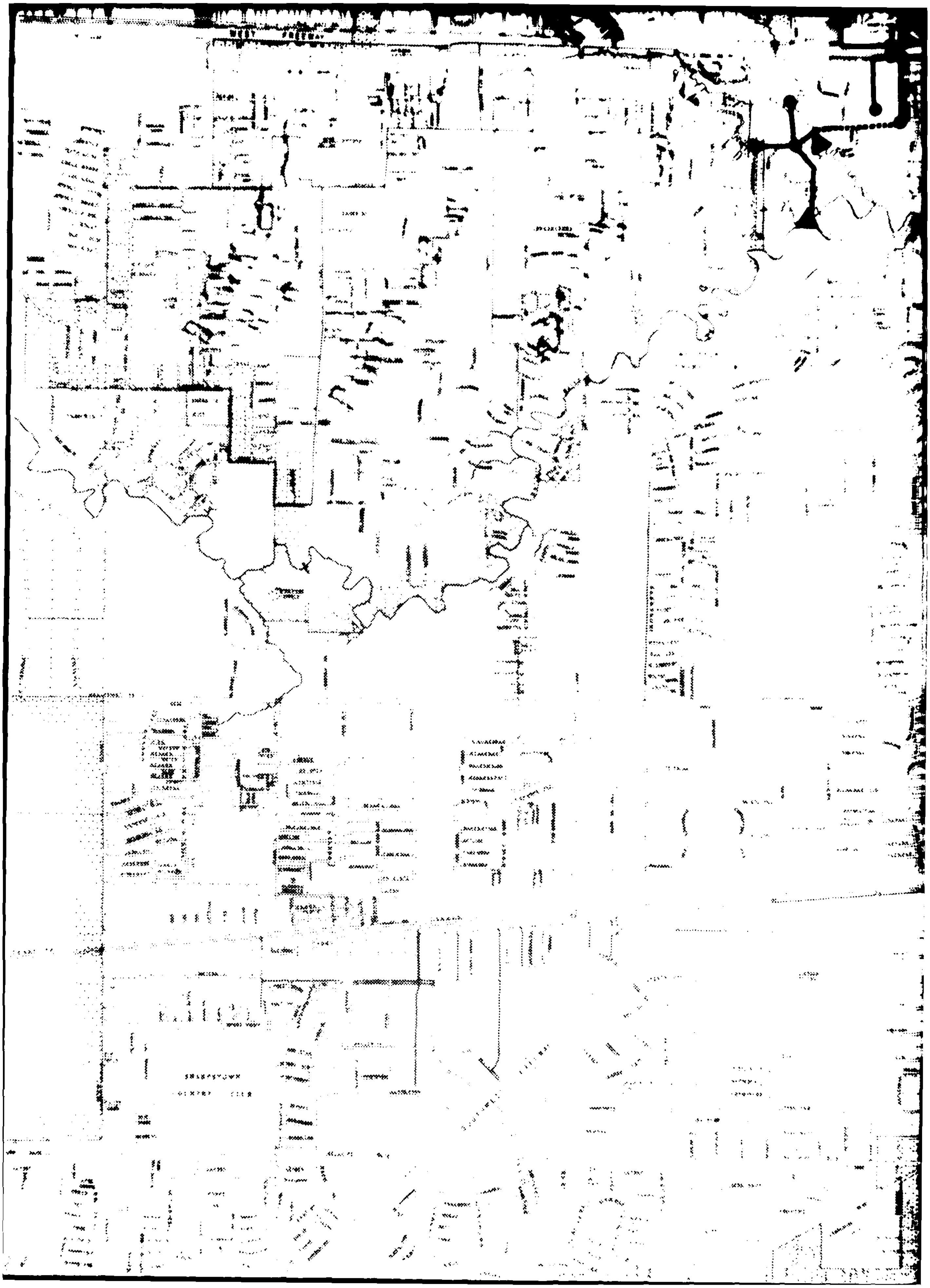
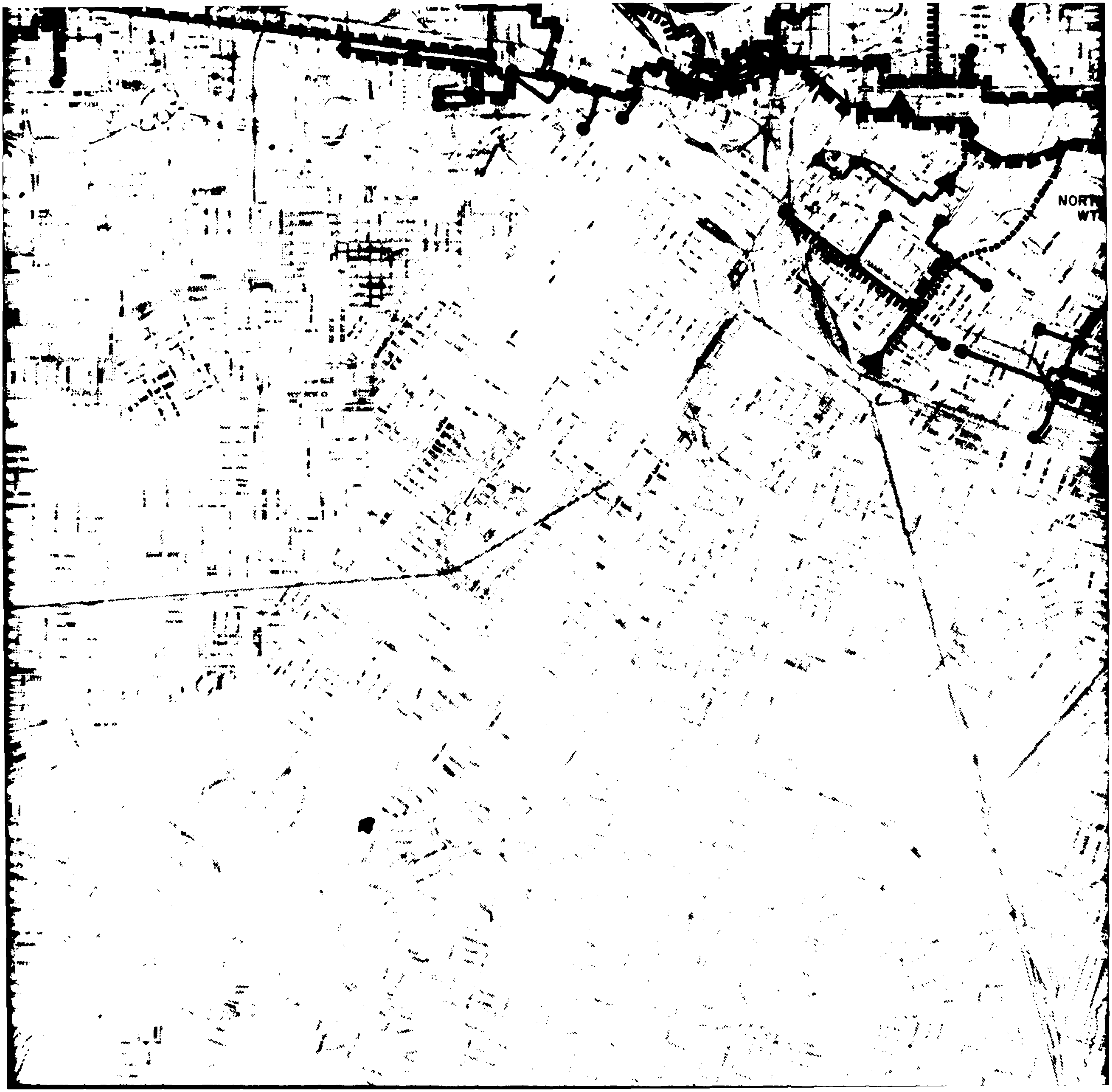


CITY OF HOUSTON
NORTHSIDE MASTER PLAN

SYSTEM ADEQUACY

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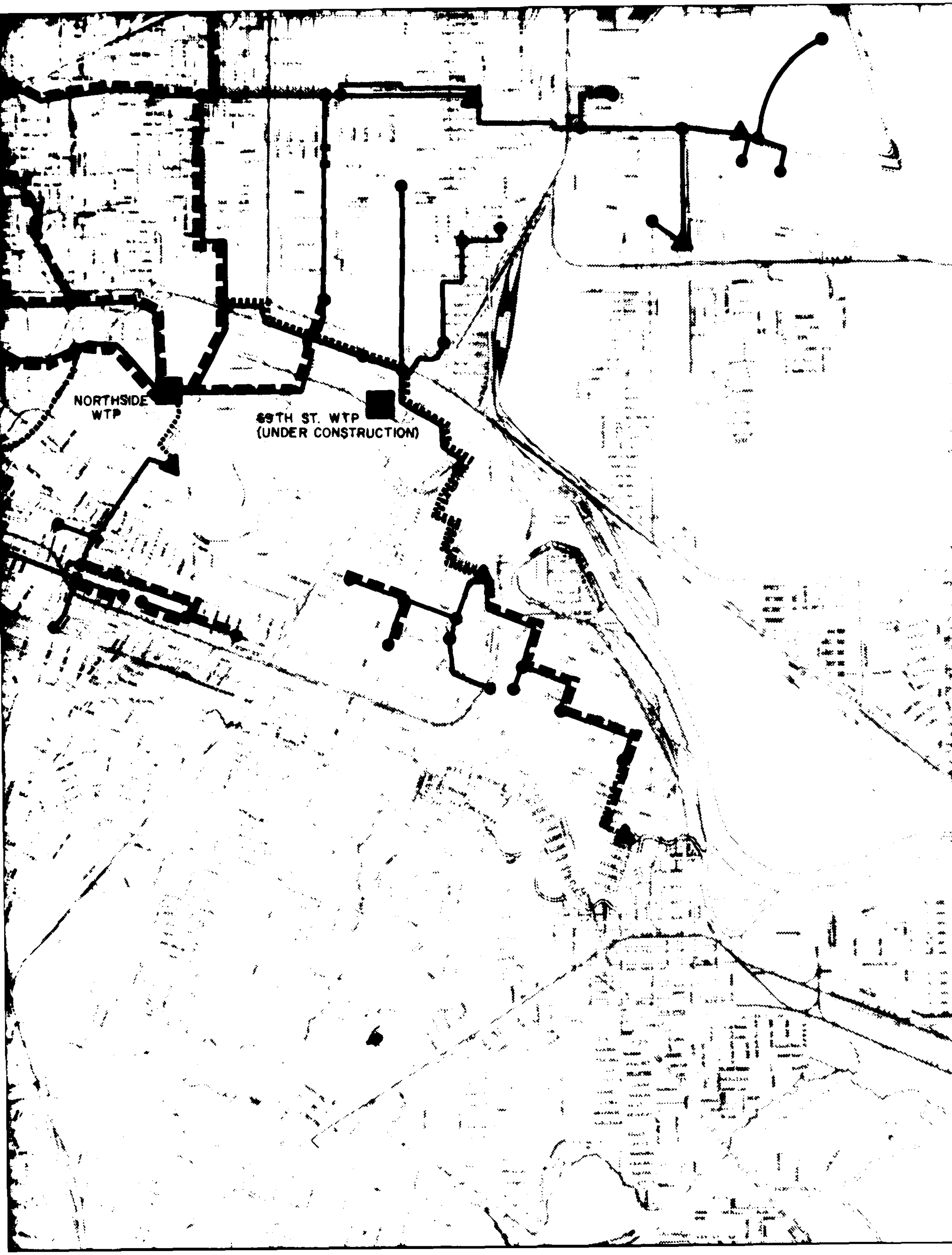

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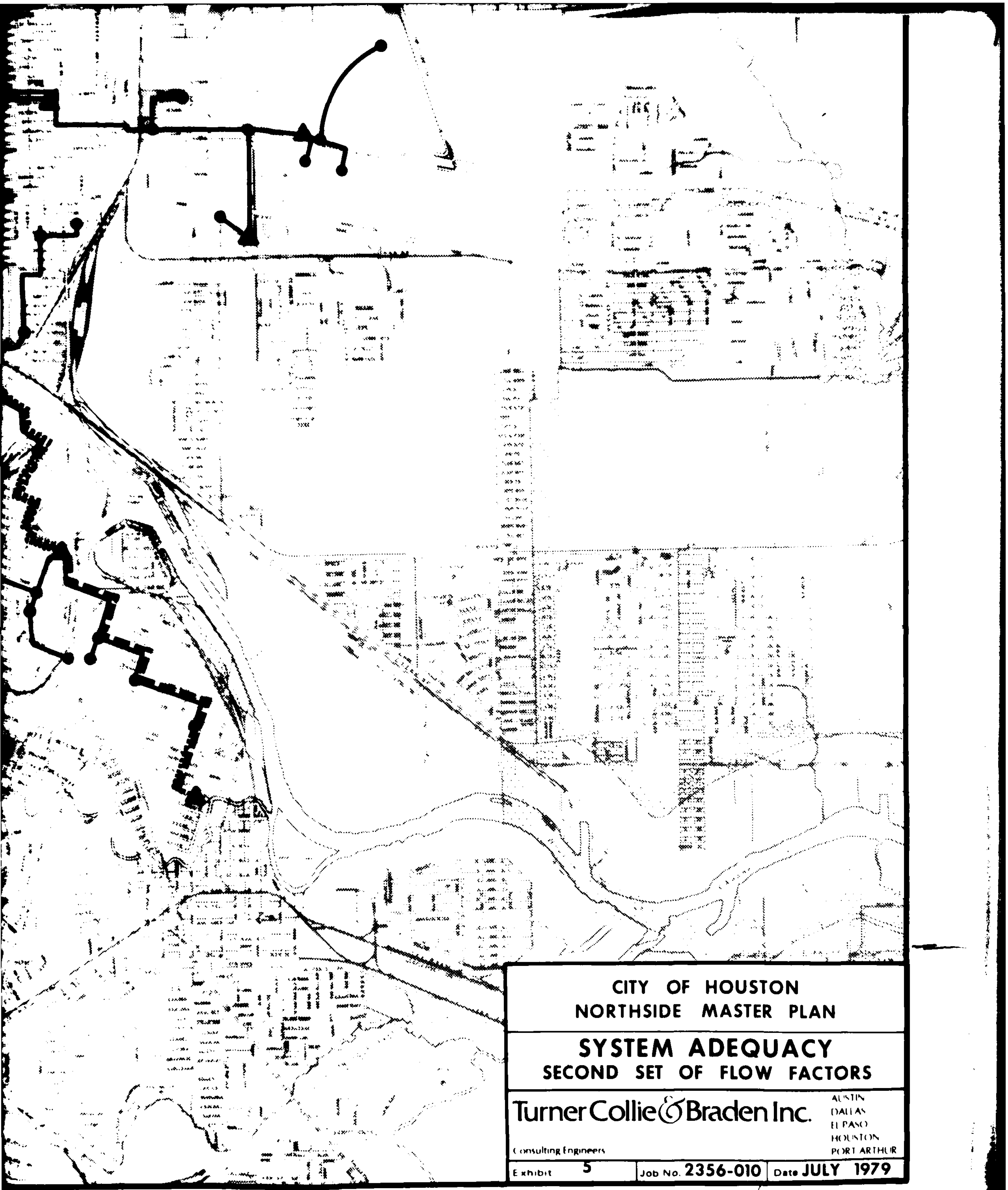

CITY OF HOUSTON
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SYSTEM ADEQUACY
SECOND SET OF FLOW FACTORS

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DALLAS
EL PASO
HOUSTON
PORT ARTHUR

Exhibit 5 | Job No. 2356-010 | Date JULY 1979

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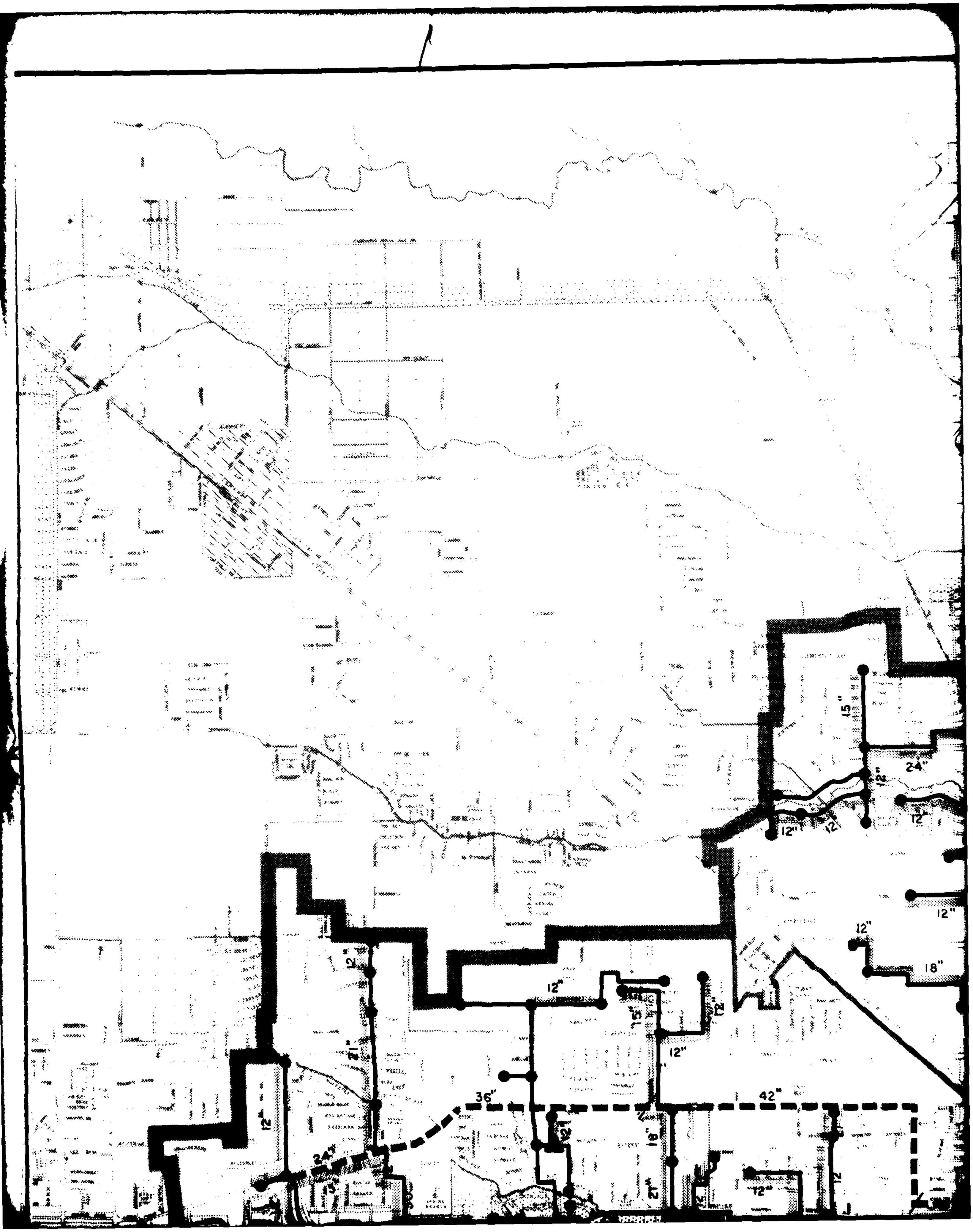
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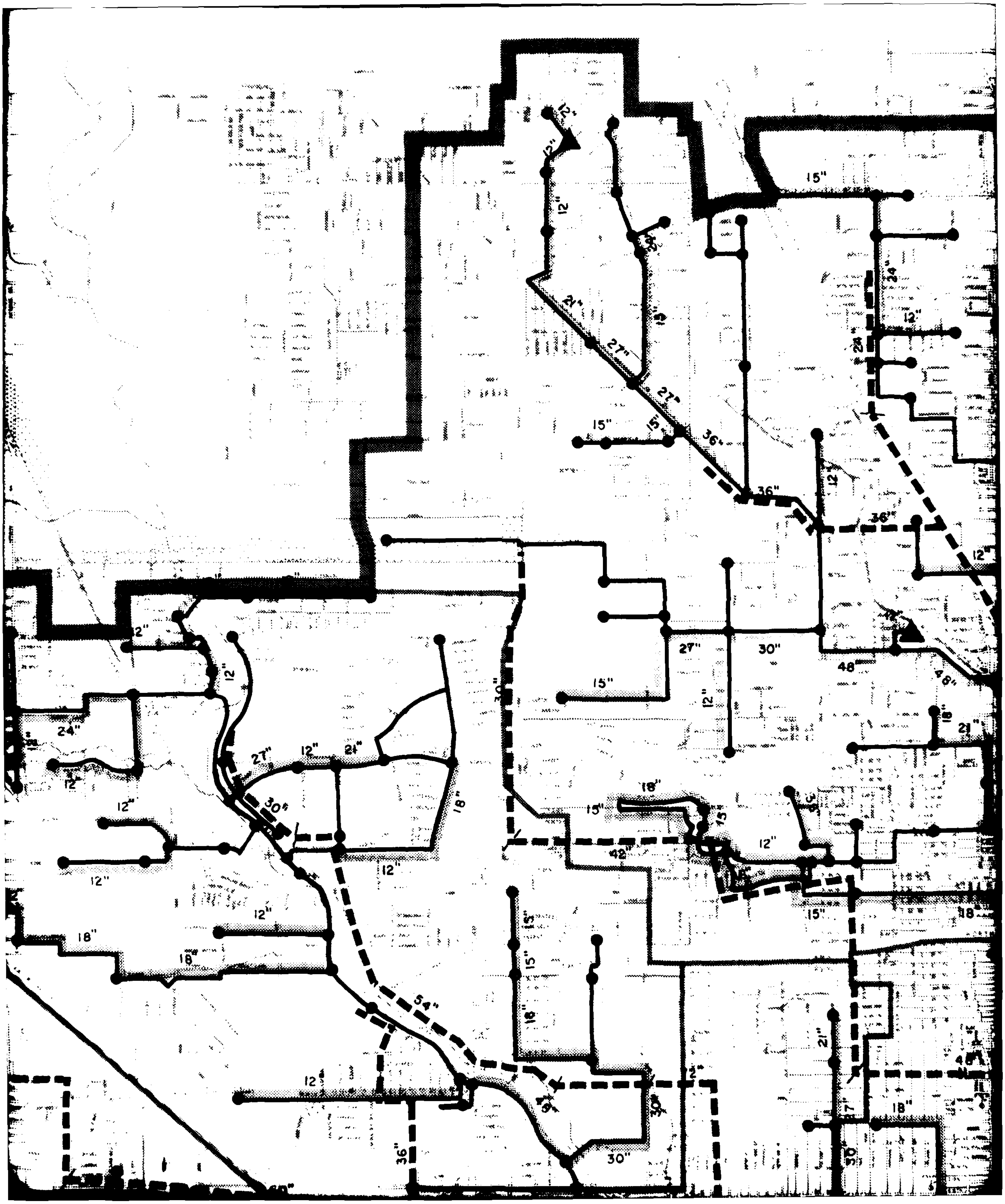

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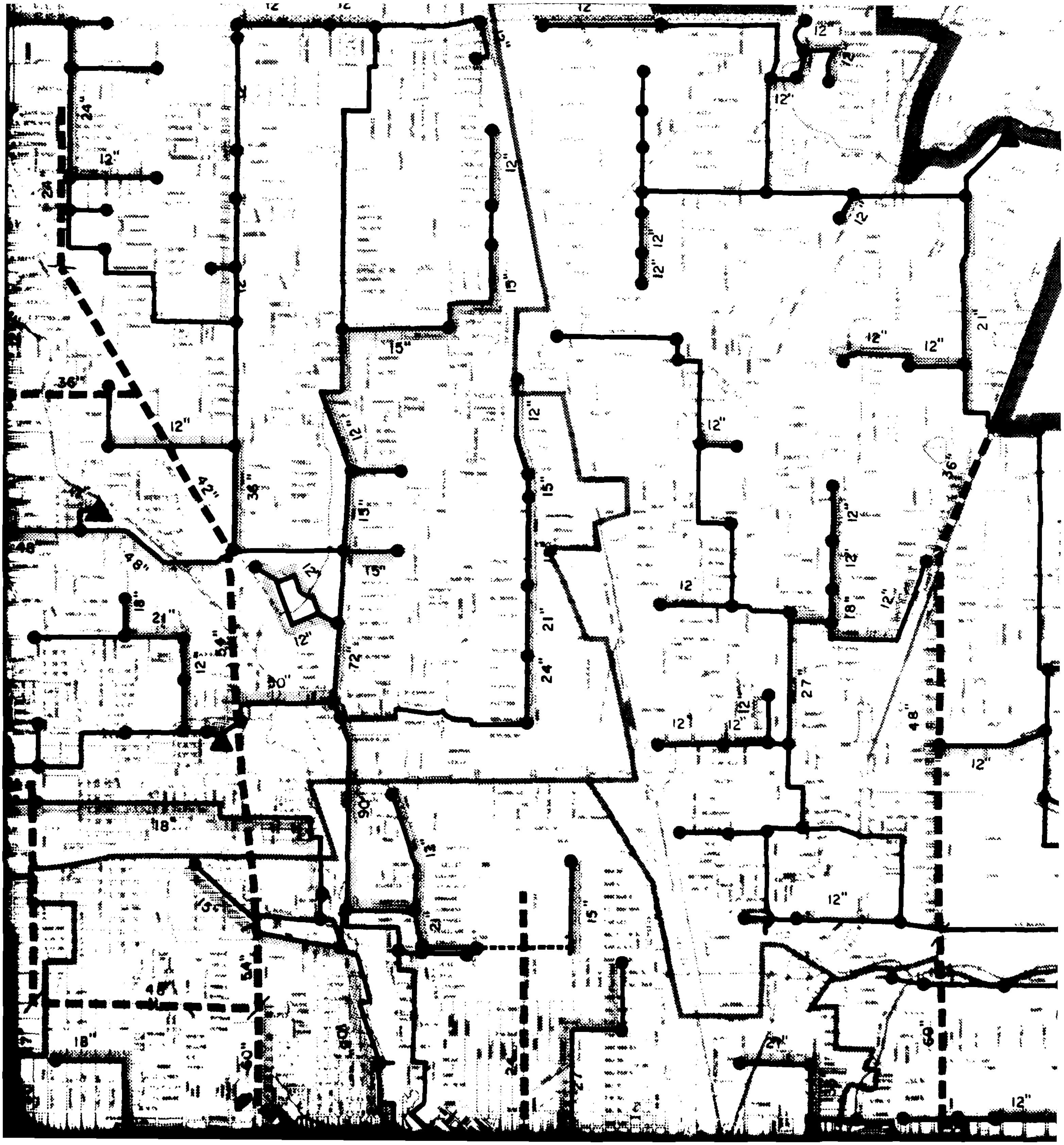

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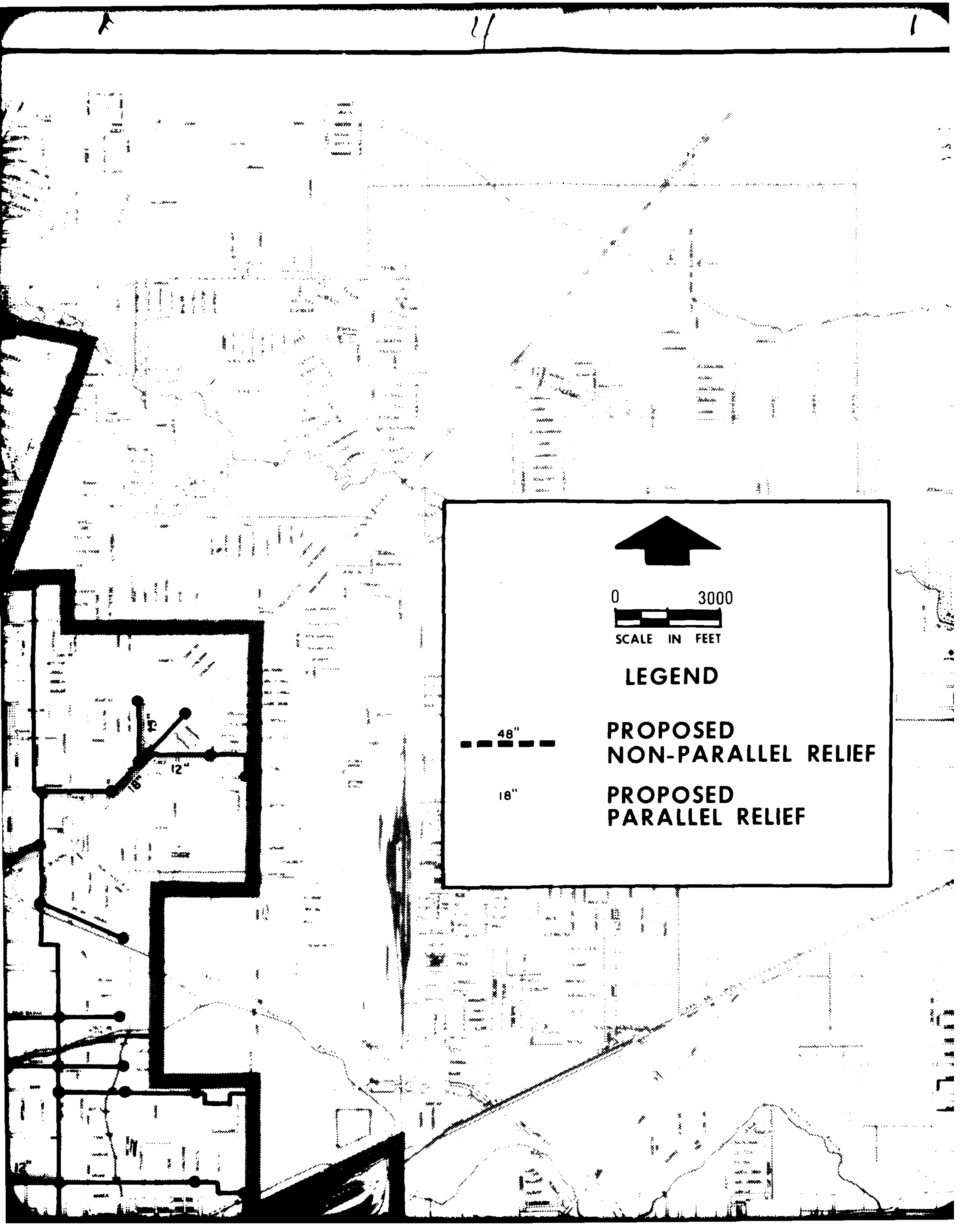

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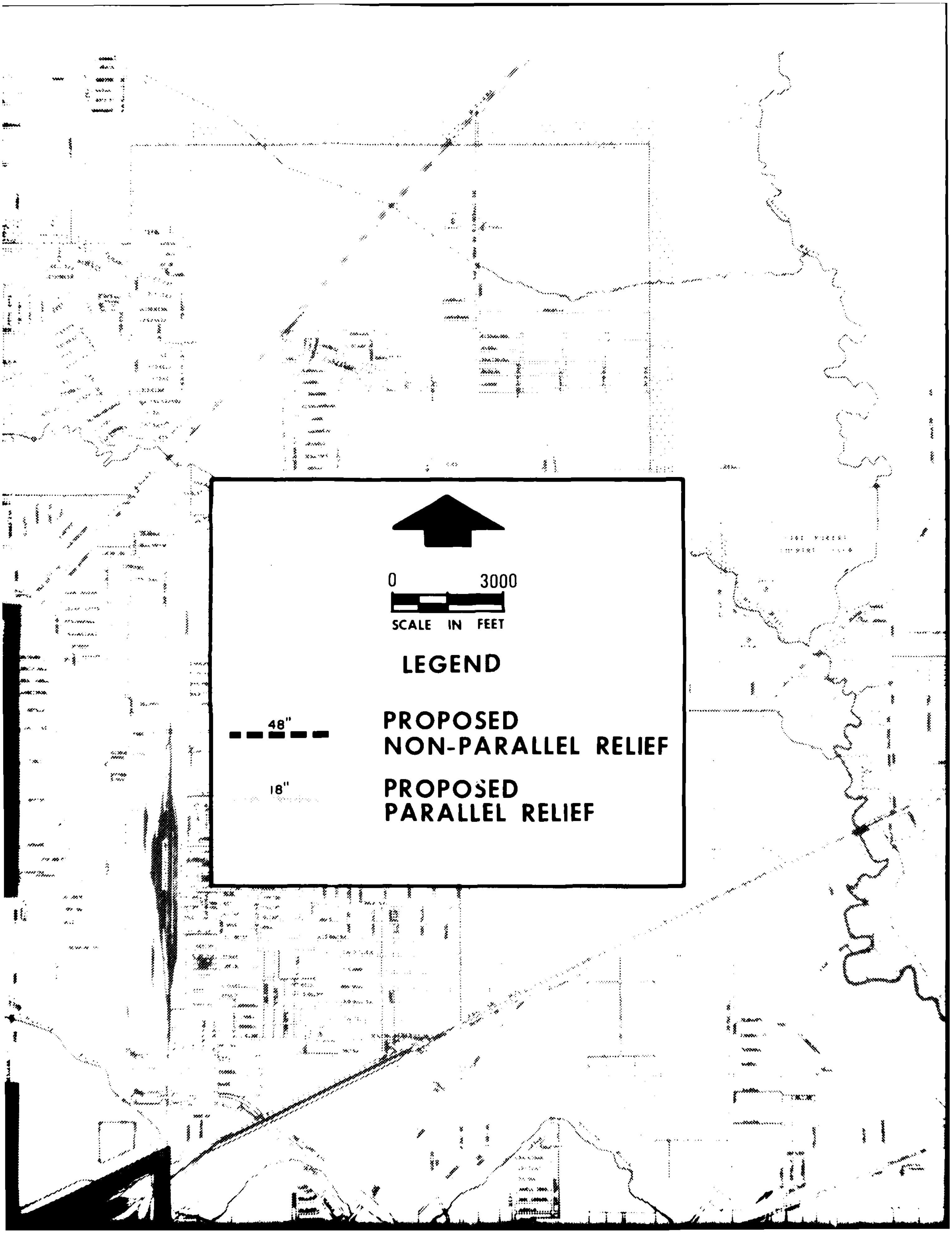
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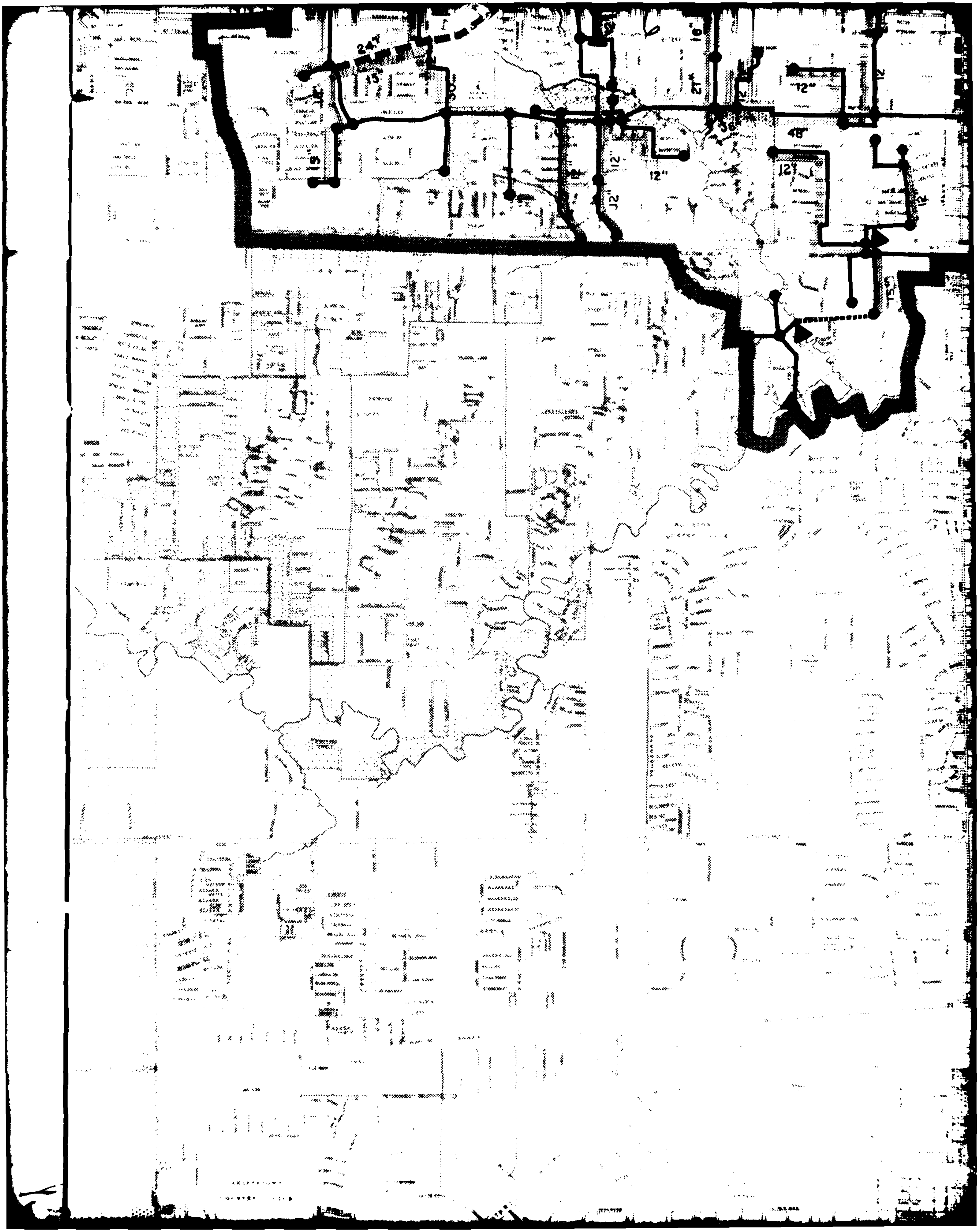

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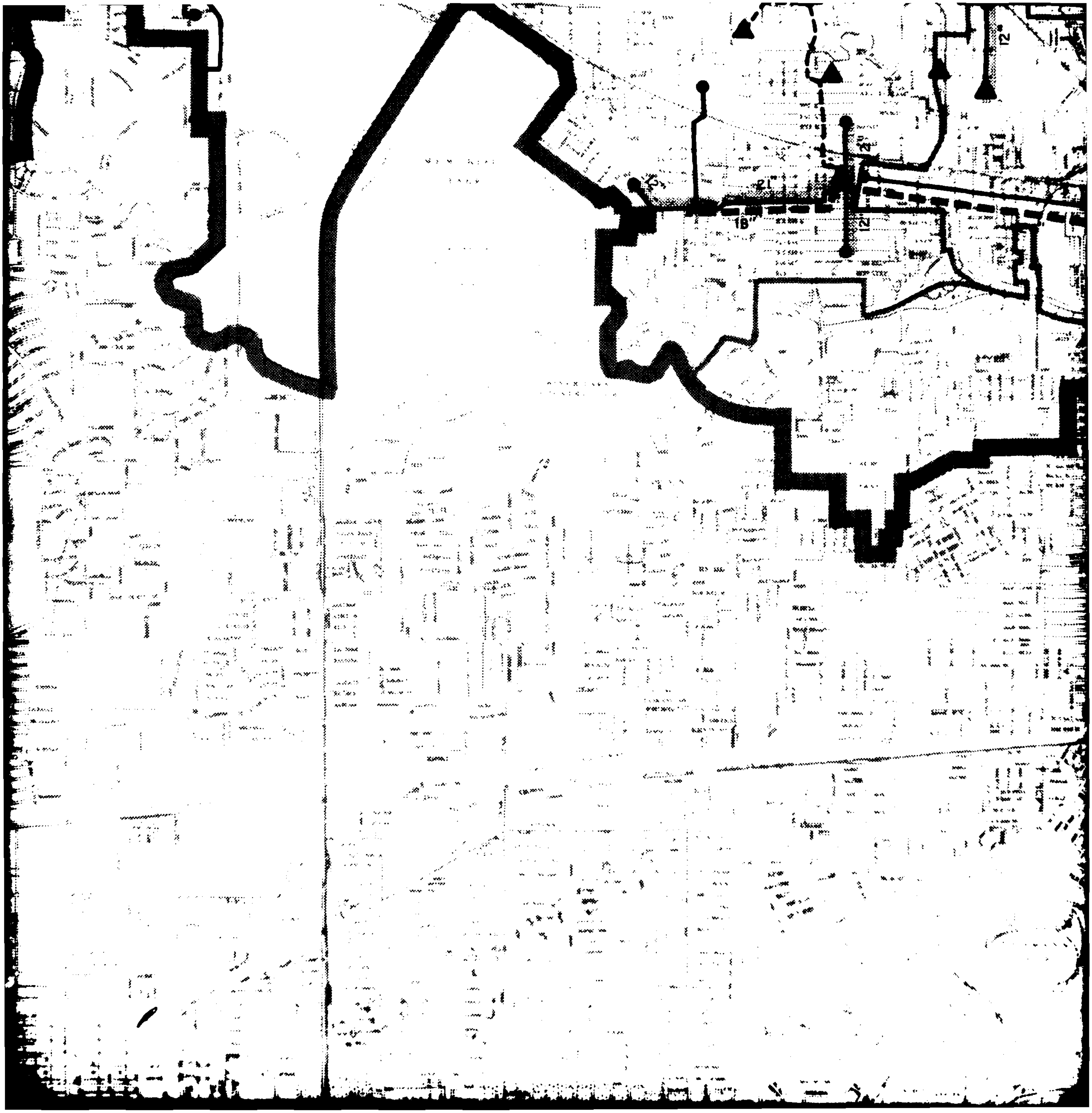
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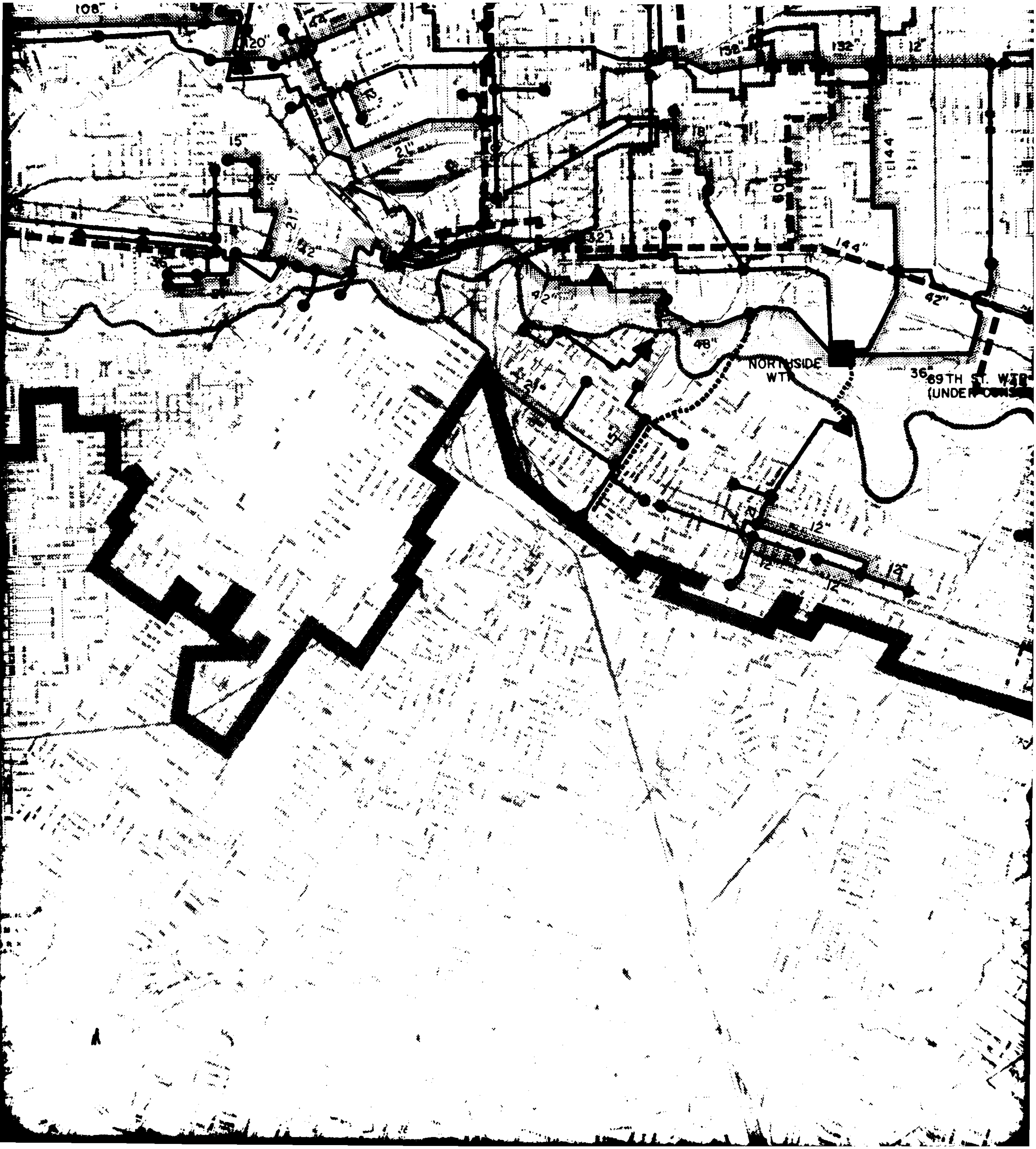
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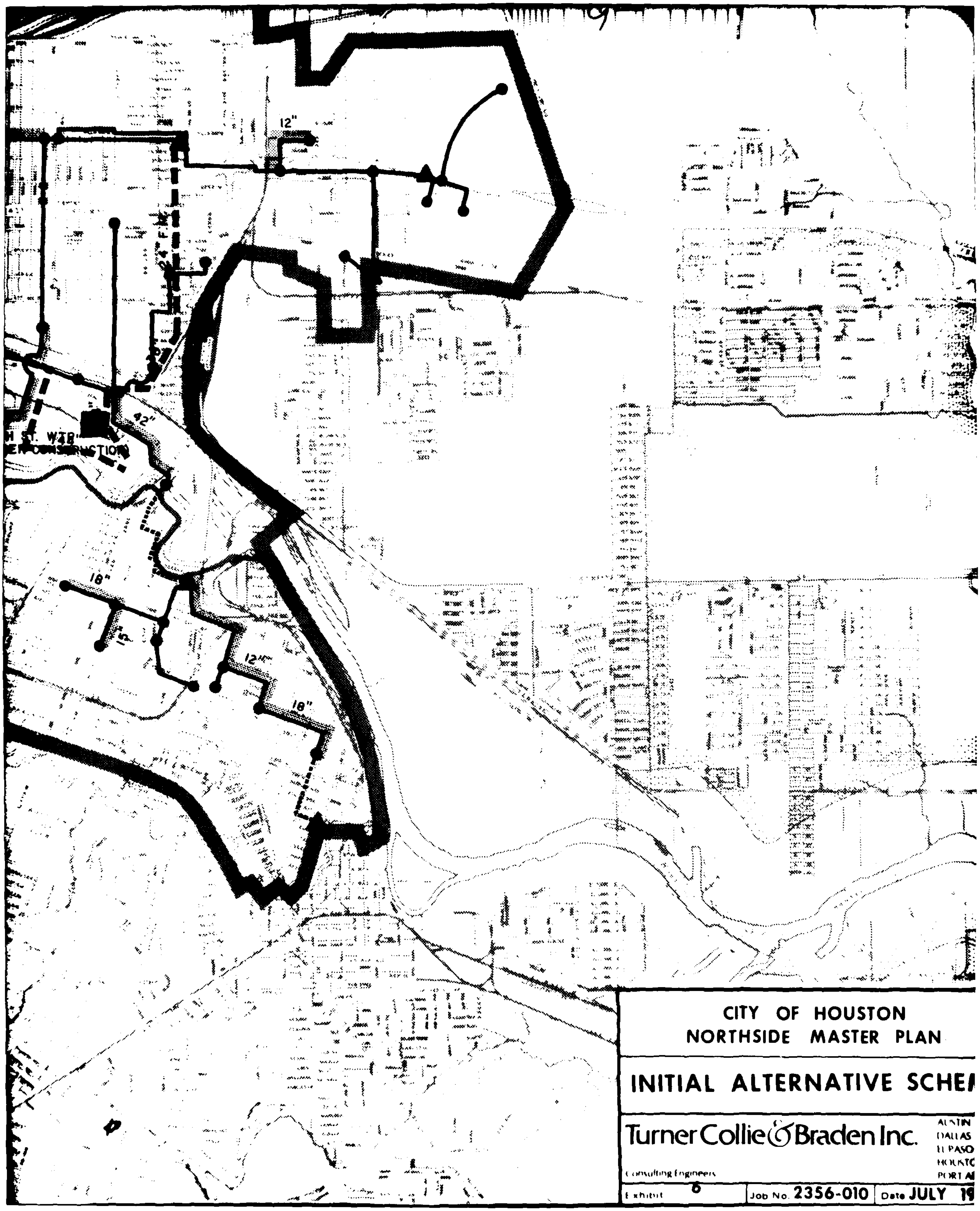

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Consulting Engineers

AUSTIN
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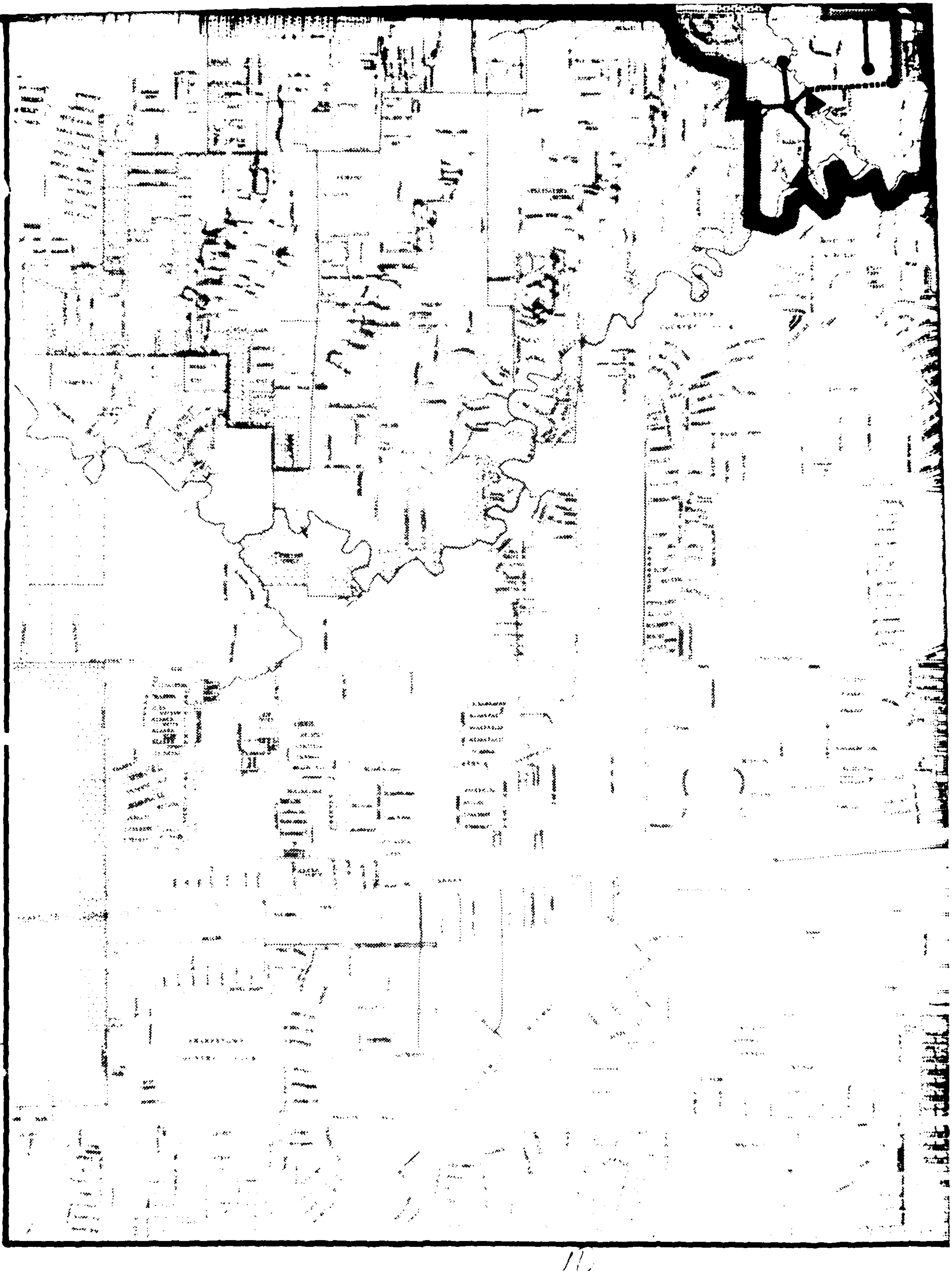
PORT A

Exhibit 6 | Job No. 2356-010 | Date JULY 19



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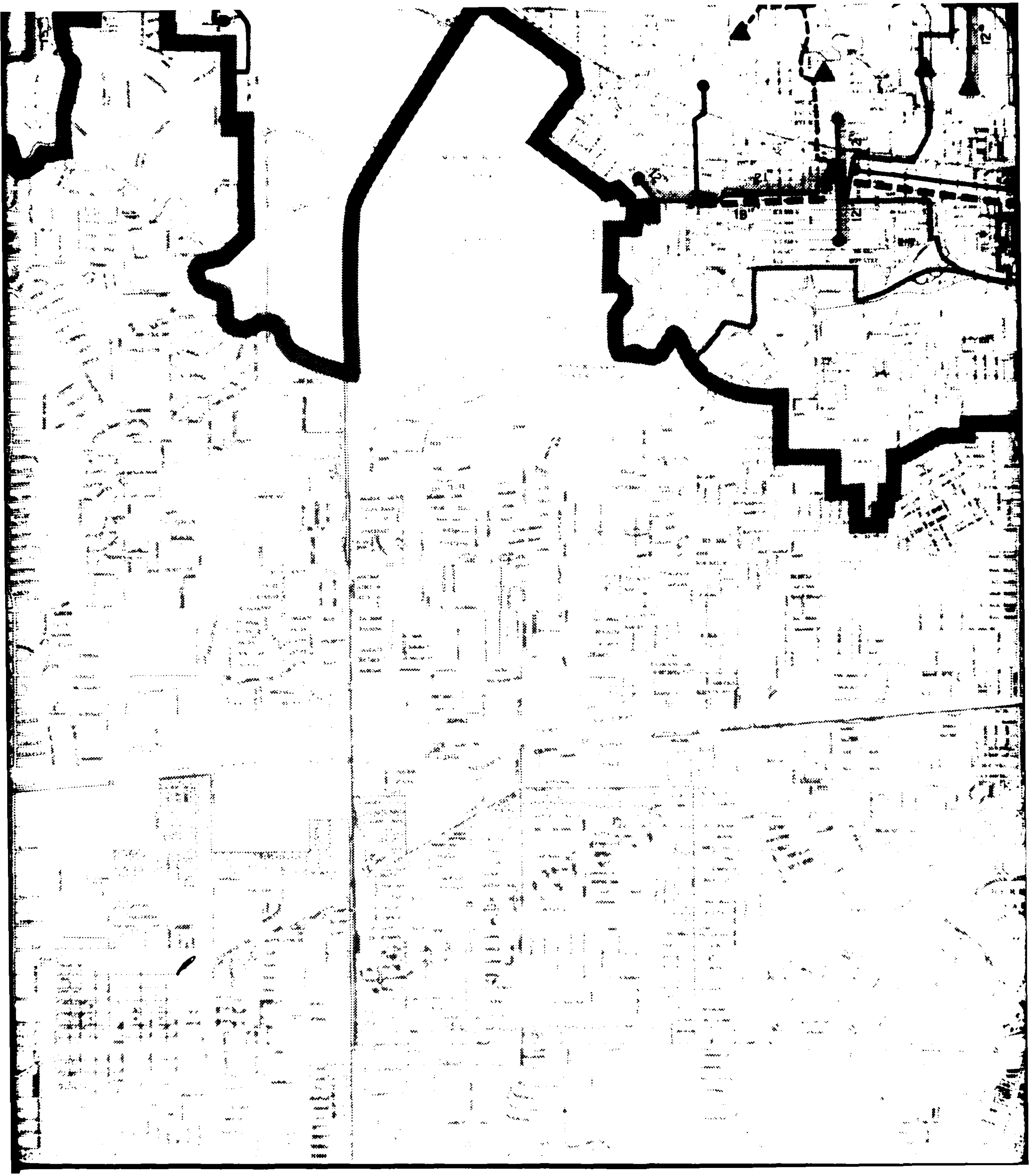

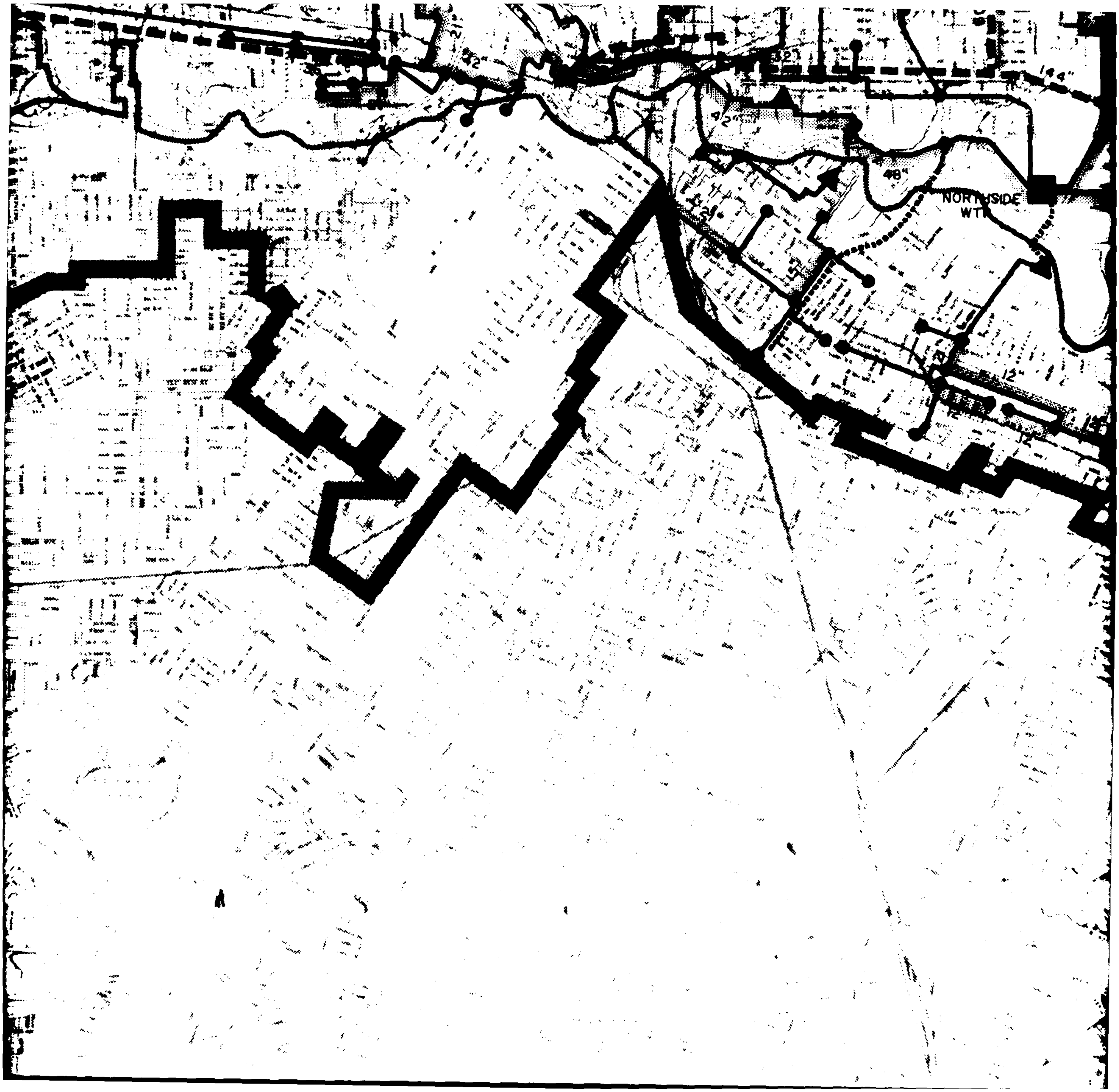

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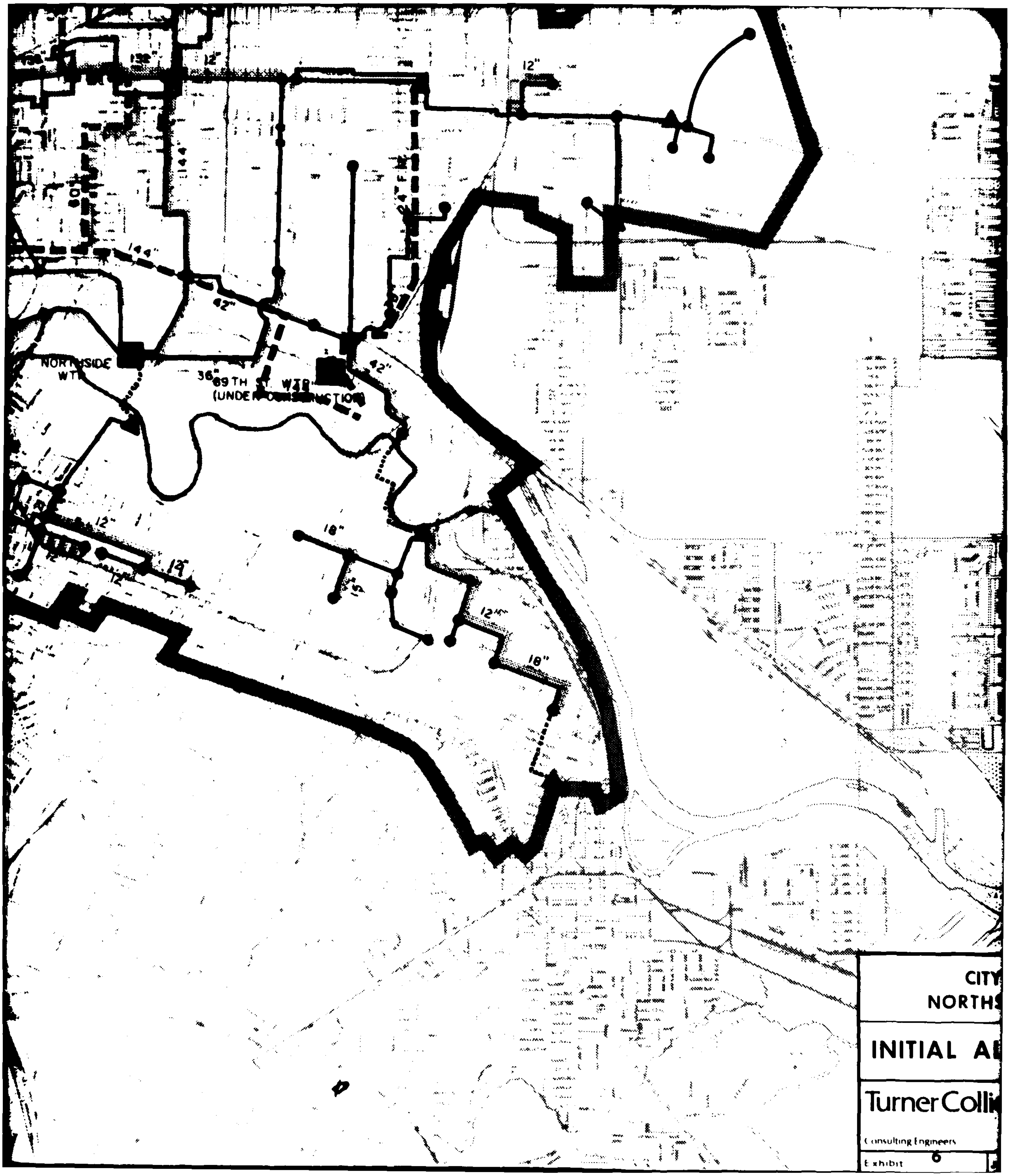

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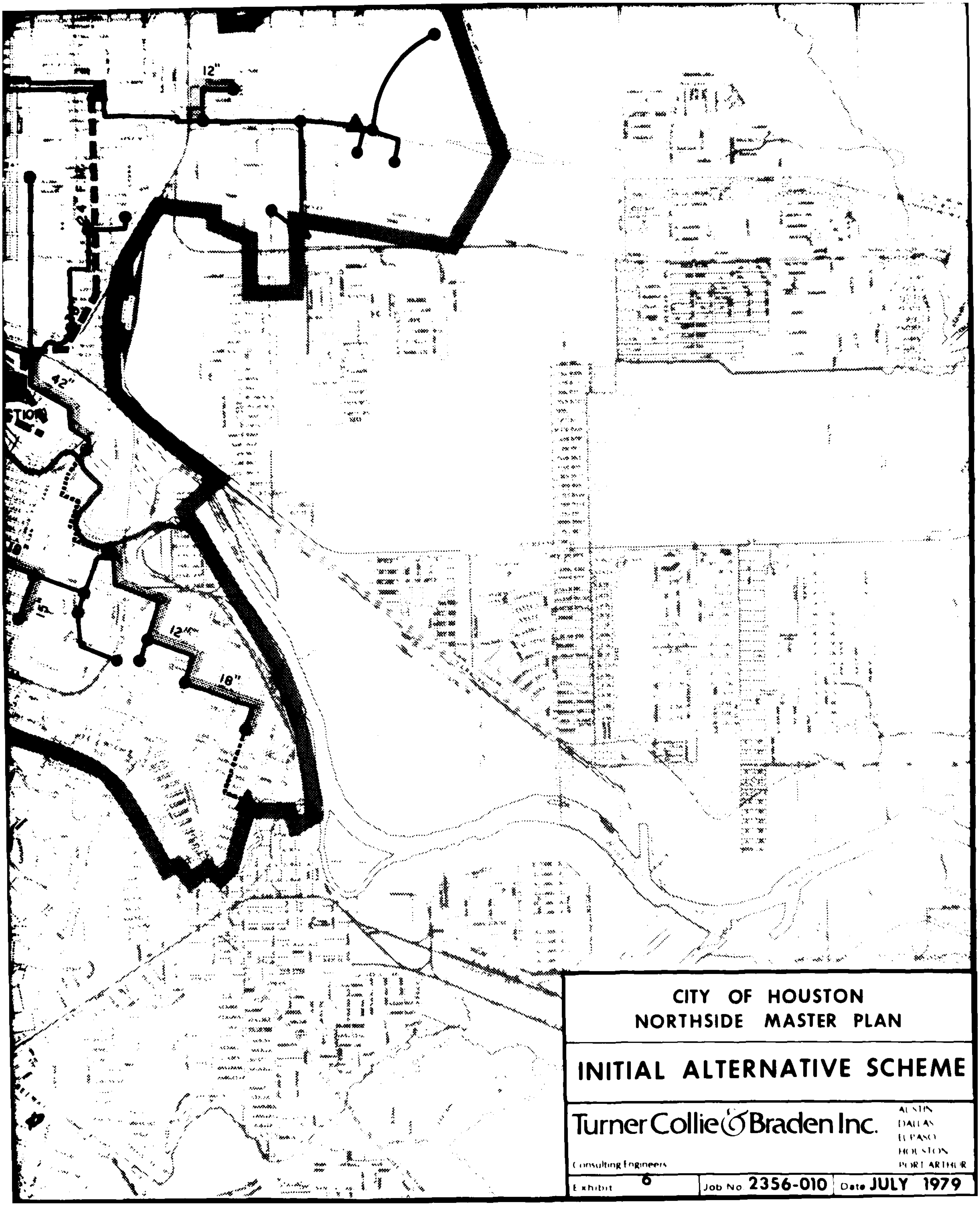

CITY OF HOUSTON
NORTHSIDE MASTER PLAN

INITIAL ALTERNATIVE SCHEME

Turner Collie & Braden Inc.
Consulting Engineers

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EL PASO
HOUSTON
PORT ARTHUR

Exhibit 6 | Job No. 2356-010 | Date JULY 1979

APPENDIX E

Job No. 2356-010-2

USER'S MANUAL FOR SANSEW:

A Computer Program to Analyze and Design Sanitary Sewer Networks

May 1979

TABLE OF CONTENTS

1.0 INTRODUCTION

The computer program described in this User's Manual and hereafter referred to as "SANSEW" provides a means to 1) analyze for sufficiency existing sanitary sewer systems and 2) to design new systems within the framework of the 1979 master planning methodology of Turner Collie & Braden Inc.

The program is limited to gravity flow networks in which the quantities of sewage generated are estimated based upon flow factors corresponding to different types of land use.

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2.0 INPUT

2.1 Deck Stacking

The deck stacking is in the following order. Each element of the stacking will be described later in this manual.

Control Cards - Beginning of execution
Main Program
Control Cards - Intermediate
Data to be Entered
Control Cards - End of Execution

2.1.1. Control Cards - Beginning of Execution

These five cards include the following in the order below:

"Ident" card
User identification card
Option FORTRAN card
FORTRAN card
Incode IBMEL card

Figures 1 through 5 show examples of each card above.

2.1.2. Main Program Cards

A listing of the main program is included as Appendix A. Two of the cards that change from run to run are those that indicate the year for which the flow projection is to be made. Examples of these cards are depicted in Figures 6 and 7. In addition to Figures 6 and 7 certain other main program cards need to be adjusted depending upon the type of run. These additional cards will be illustrated later in this manual.

2.1.3. Control Cards - Intermediate

Three intermediate control cards required for each run are:

Execute card (Figure 8)
Data card (Figure 9)
Limits card (Figure 10)

2.1.4. Data Cards

Data is entered into the deck in the following order:

Flow Factors Card (Figure 11)
Acres Cards (Figure 12)
Pipe Nomenclature (Figure 13)
Minisystem Cards (Figure 14)
Network Flow Accumulation Cards (Figure 15)
MALCAP Control Card (Figure 16)
Capacity Computation Cards if MALCAP = 0 (Figures 17-19)

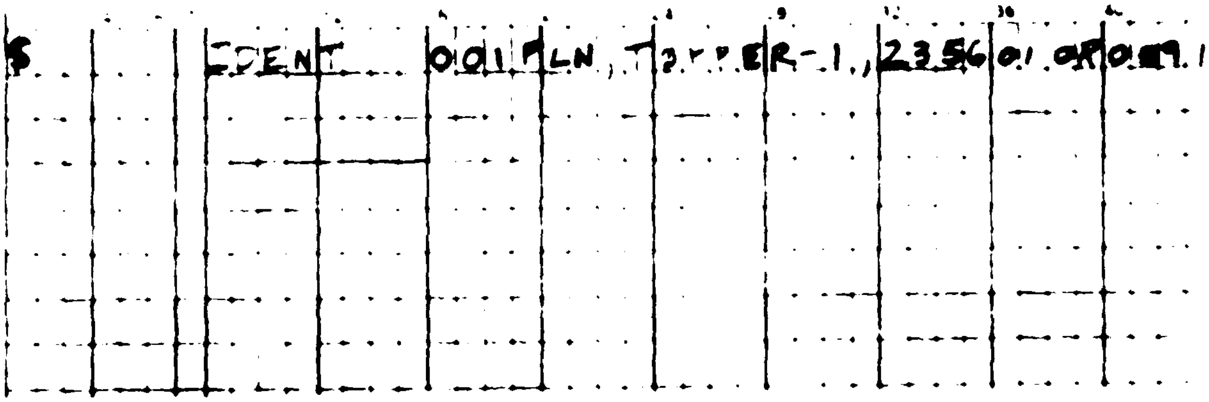


FIGURE 1 - IDENT CONTROL CARD

Notes:

1. Columns 16-21 contain the User ID.
2. Columns 23-30 contain any descriptor.
3. Columns 32-38 contain the job number.
4. Columns 39-43 contain the employee number.

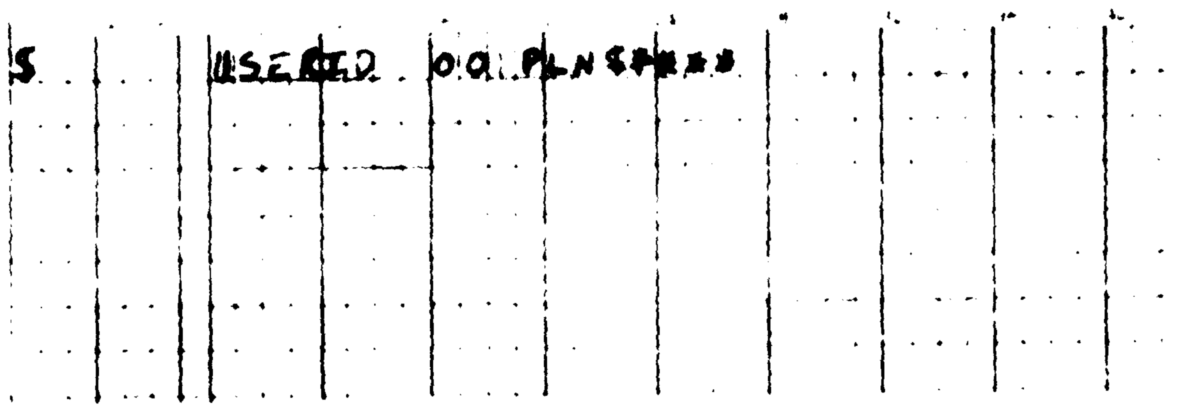


FIGURE 2 - USER IDENTIFICATION CARD

Notes:

1. Columns 16-21 contain the User ID.
2. Columns 23-26 contain the password.

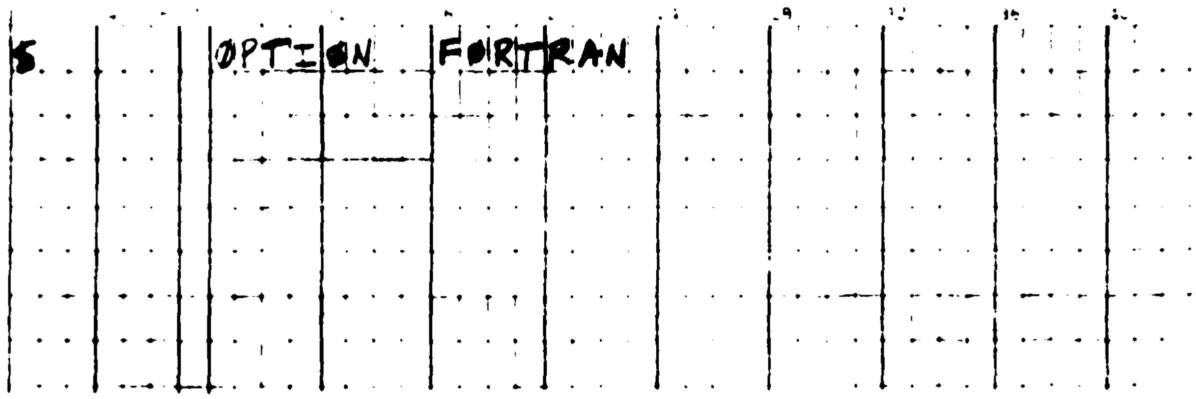


FIGURE 3 - OPTION FORTRAN CARD

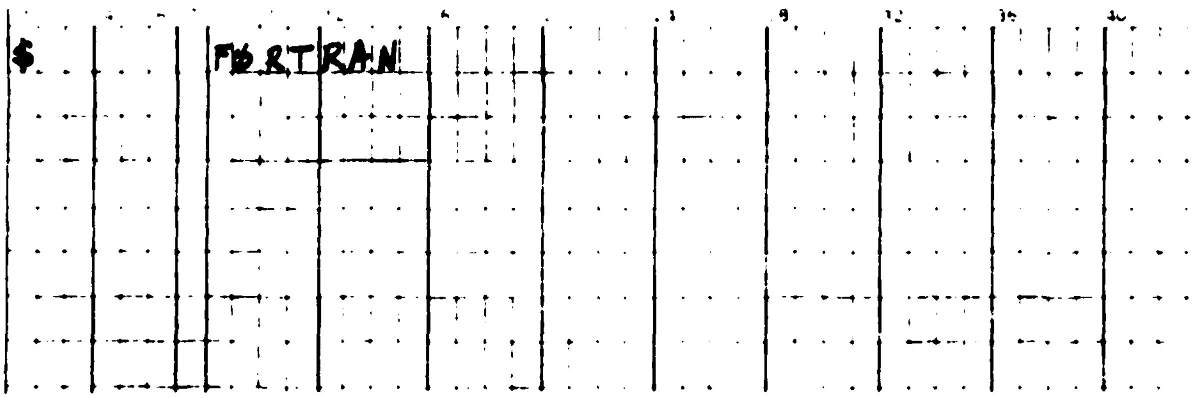


FIGURE 4 - FORTRAN CARD

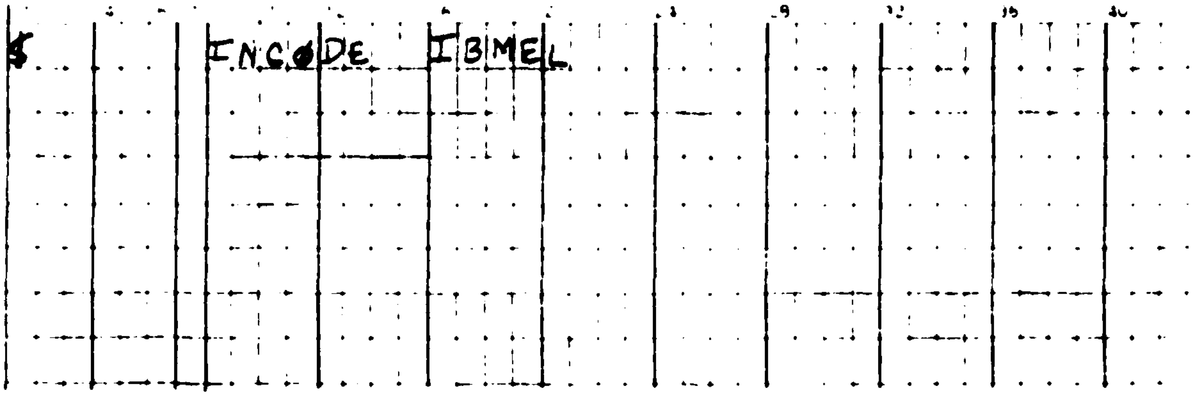


FIGURE 5 - INCODE IBMEL CARD

```
79  FORMAT(1X,'PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000'//)          63
```

FIGURE 6 - MAIN PROGRAM CHANGE CARD

Note:

Columns 65-68 change depending on year of flow projection.

```
   80 FØRMAT(1X,'FLØW FACTØRS FØR THE YEAR 2000 ARE SHØWN BELØW:'/)          65
```

FIGURE 7 - MAIN PROGRAM CHANGE CARD

Note:

Columns 44-47 change depending on year of flow projection.

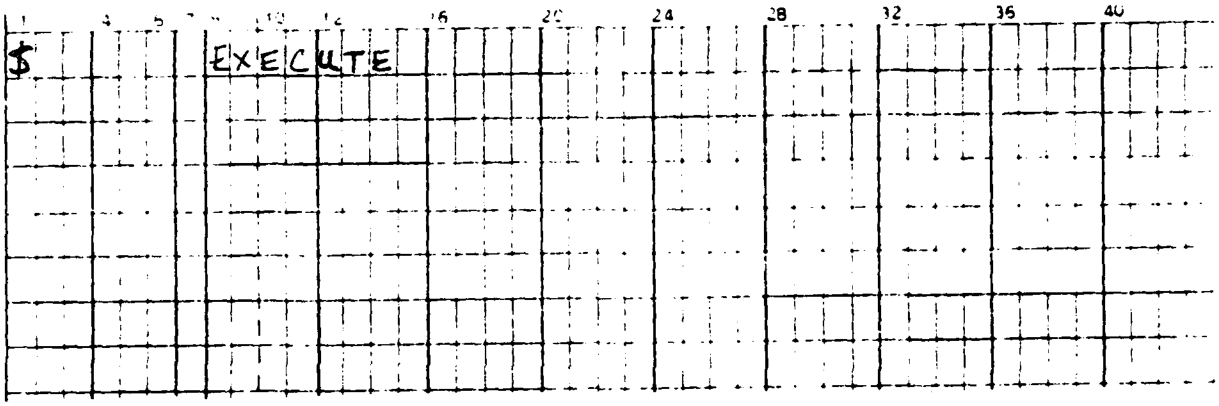


FIGURE 8 - INTERMEDIATE CONTROL CARD - EXECUTE CARD

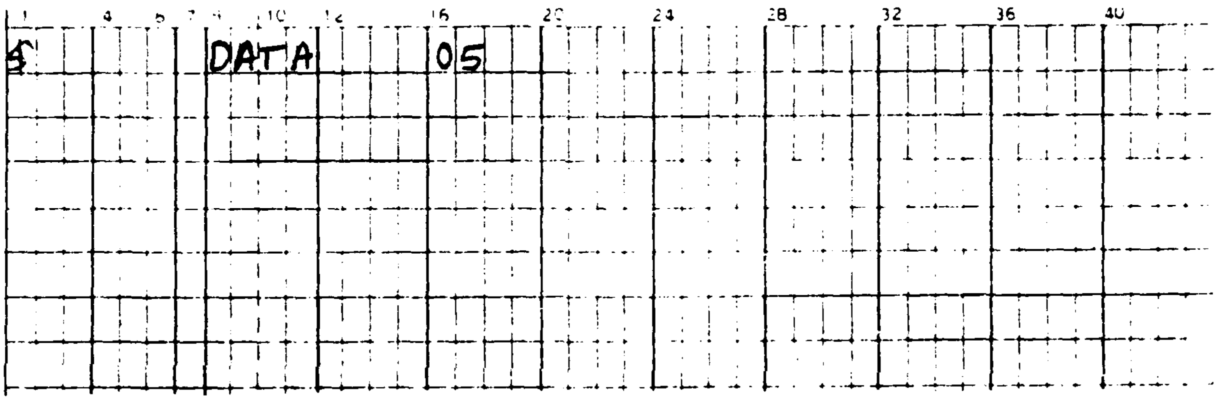


FIGURE 9 - INTERMEDIATE CONTROL CARD - DATA CARD

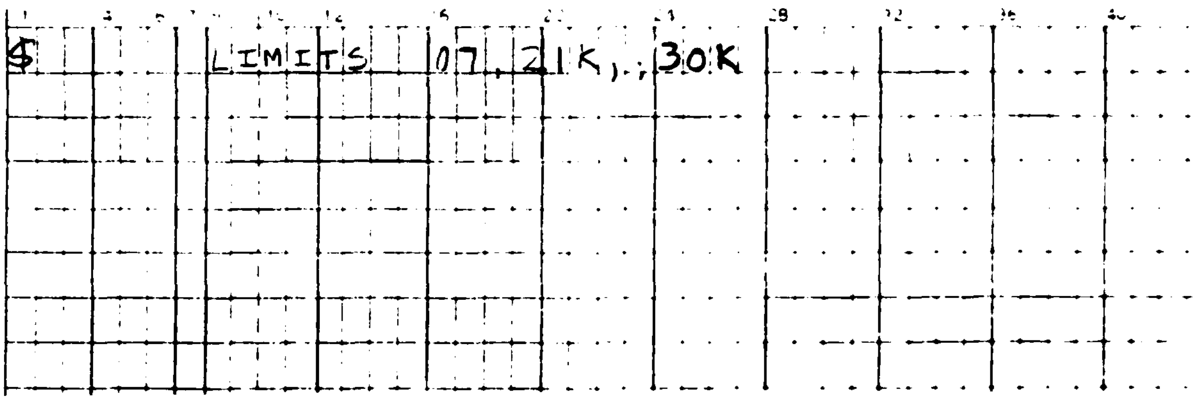


FIGURE 10 - INTERMEDIATE CONTROL CARD - LIMITS CARD

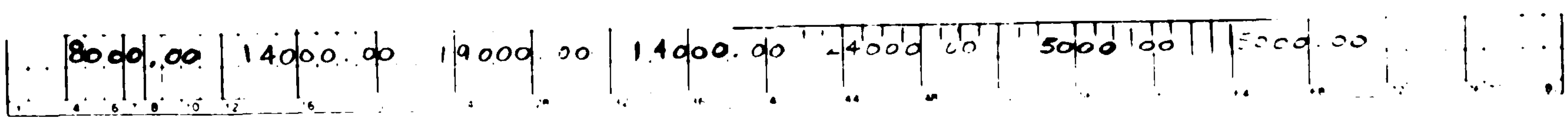


FIGURE 11 - FLOW FACTORS CARD

Notes:

1. Format is 7F 10.2.
2. Units are gallons per acre per day.
3. Numbers correspond to land use category as follows:

Columns	Land Use
4-10	Single Family Residential
13-20	Multi-Family Residential - Low Density
23-30	Multi-Family Residential - High Density
33-40	Commercial - Low Density
43-50	Commercial - High Density
54-60	Industrial
64-70	Institutional

PROGRAM CODING FORM

83

PROJECT Northside San Sew	CHARACTER SET		SOURCE LANGUAGE	PAGE 19 OF 54
PROGRAM TOPPER I		DATE SUBMITTED	REMARKS Average Input	
PROGRAMMER Dennis R. Topper USER 001PLN JOB 2356-010 EMP 0591		DATE REQUIRED		

70.45	0.00	5.20	14.68	0.00	0.00	2.09
148.46	0.00	16.47	7.53	0.00	6.43	9.08
167.49	3.04	63.97	19.01	0.00	27.59	0.00
5.49	0.00	7.92	21.29	0.00	3.05	0.00
236.63	0.00	17.35	36.71	0.00	12.89	0.00
67.42	3.84	7.25	18.17	0.10	0.10	0.00
138.77	0.00	3.19	0.00	0.00	0.00	0.00
183.91	3.26	13.97	8.25	6.20	10.17	0.00
5.02	0.00	8.29	54.42	0.00	23.25	23.37

FIGURE 12 - TYPICAL ACRES CARDS CODING. FORMAT 7F7.2.

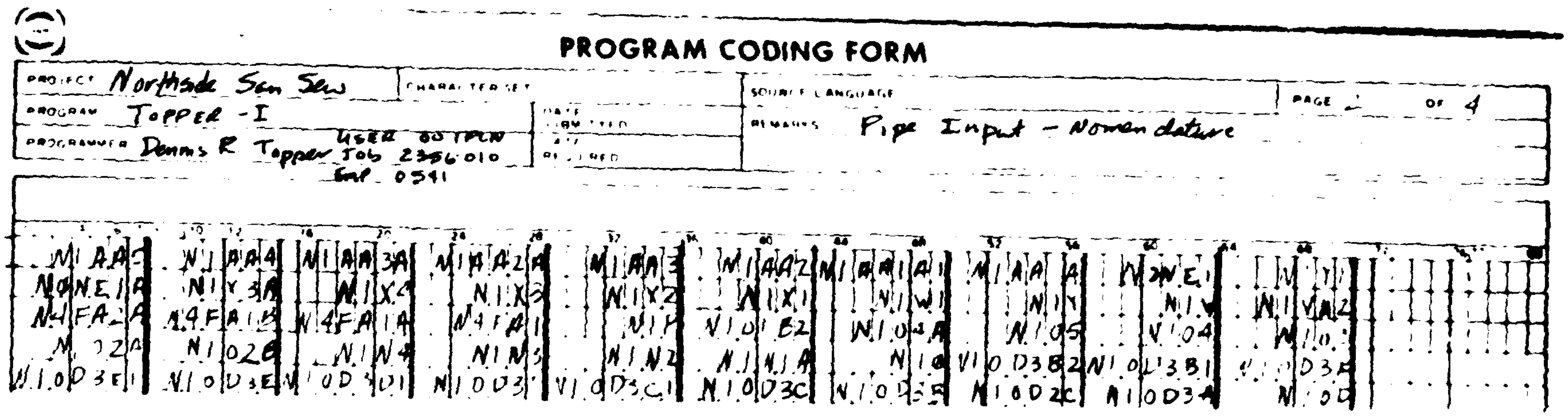


FIGURE 13 - TYPICAL PIPE NOMENCLATURE CARDS. FORMAT 10A7.

PROGRAM CODING FORM

Northside San Sew

TUPPER - I

Dennis R Tupper

USER 001 MN
JUB 2356010
EMP 0591

Minisystem Input

2 2

#22	#23	#27	#24	#28	#43	#26	#33	#11	#31
#42	#44	#45	#46	#29	-55	#51	#53	#43	-47
#49	#53	#52	#54	F1	E2	E3	E5	F6	E4
E7	E10	F9	E11	E13	E12	E8	I1	I4	I2
I3	I10	I6	I5	I9	I14	I13	I12	I11	I18
I7	I8	I16	I15	I19	I17	I23	I24	I25	I22

FIGURE 14 - CODING FORMS FOR TYPICAL MINISYSTEM CARDS. FORMAT 10A5.

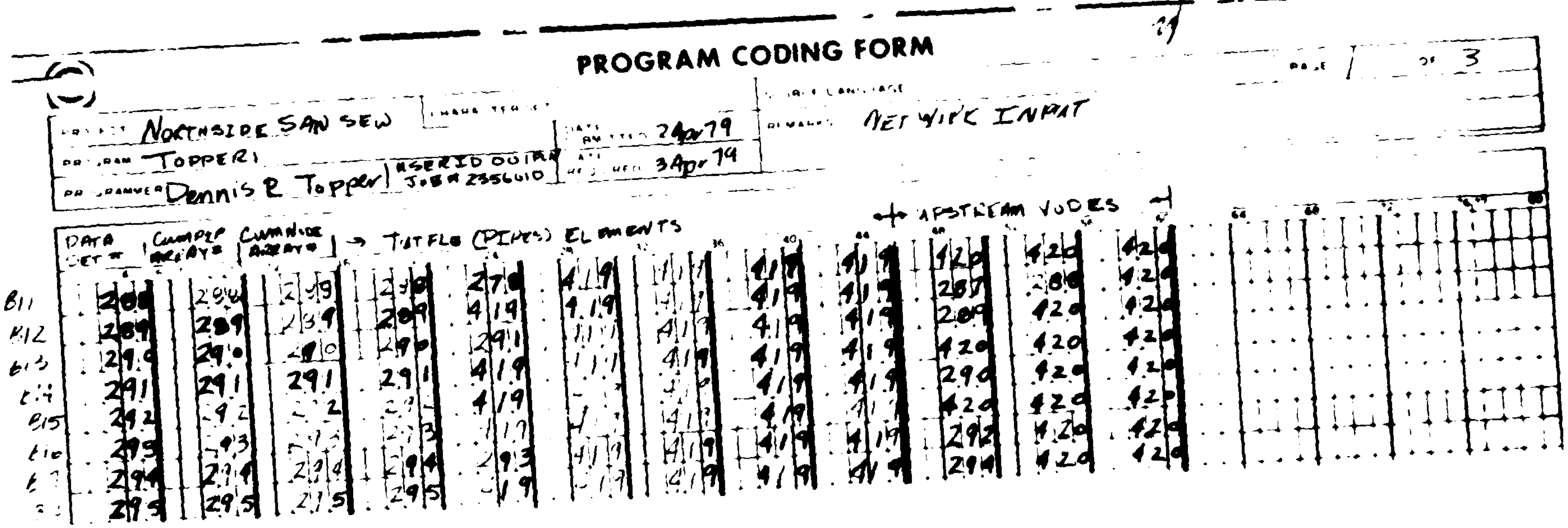


FIGURE 15 - CODING FORM FOR TYPICAL NETWORK FLOW ACCUMULATION CARDS.
FORMAT 12I5.

Note:

Alphanumeric designations to left of coding columns are minisystem names for reference.

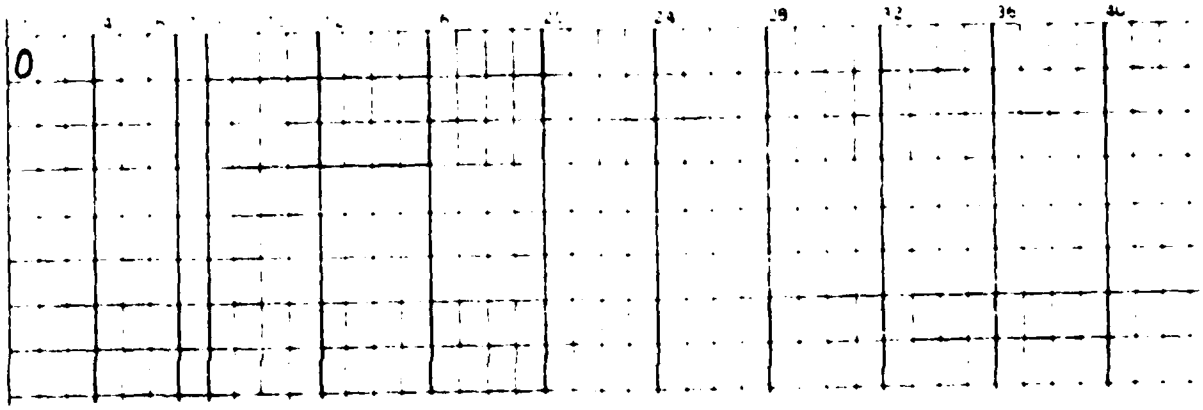


FIGURE 16 - MALCAP CONTROL CARD. FORMAT I1.

Notes:

1. A zero in column one directs the computer to calculate the capacity of each pipe in the network.
2. A one in column one indicates to the computer that capacity values will be input.

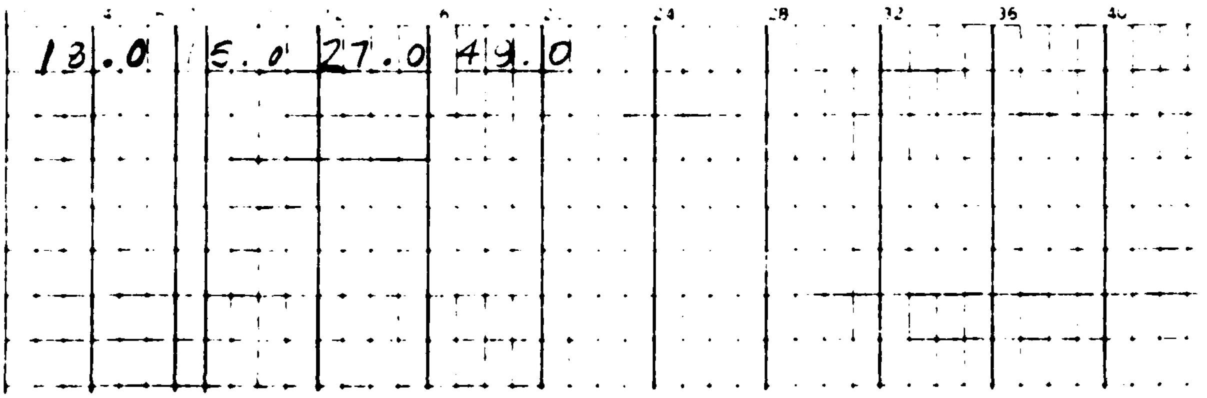


FIGURE 17 - CAPACITY COMPUTATION CARD IF MALCAP = 0.
This is the diameter input of pipe size.
FORMAT 14F5.1.

Notes:

1. The diameter input is the first to be read in the CAPCTY subroutine.
2. The above example reflects a system with only four sewer lines. Normally, the input will cover a full 70 columns instead of just the 20 shown above.
3. Units are inches.

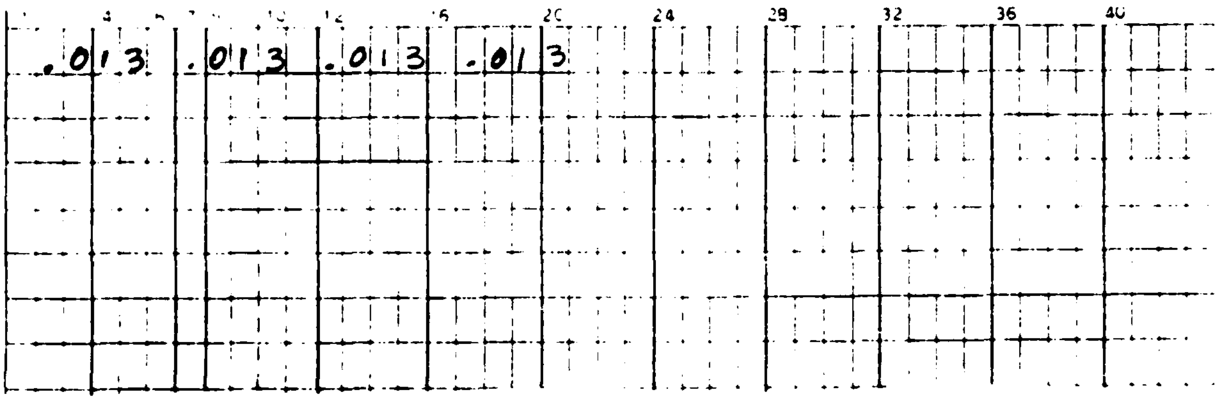


FIGURE 18 - CAPACITY COMPUTATION CARD IF MALCAP = 0.
This is the Manning's number input.
FORMAT 14F5.3.

Notes:

1. The roughness input (Manning's number) is the second input to the CAPCTY subroutine.
2. The input will usually cover a full 70 columns. Only four roughness numbers are given above because only four sewer lines are in the network.

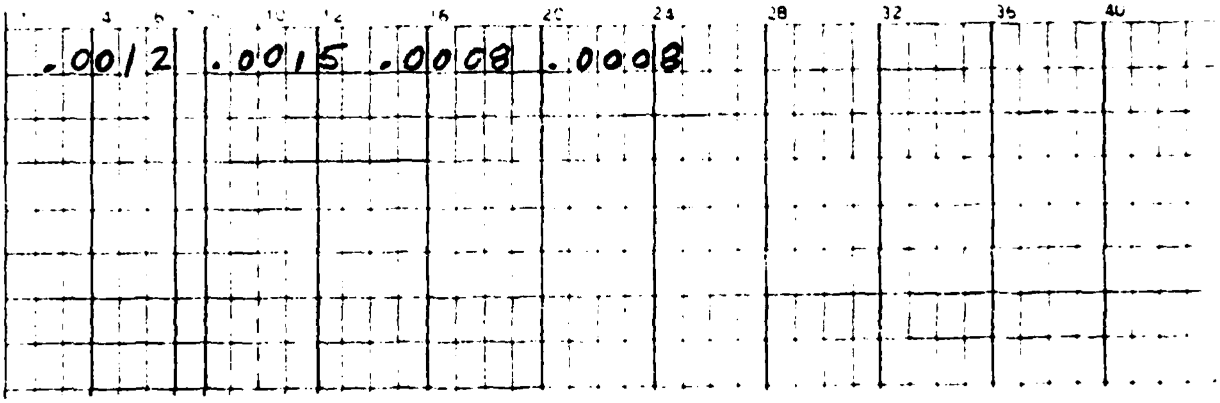


FIGURE 19 - CAPACITY COMPUTATION CARD IF MALCAP = 0
This card is slope input.
FORMAT 12F 6.4.

Notes:

1. The slope input is in feet per 1,000 feet.
2. The slope cards are third to be read in the CAPCTY subroutine.
3. Only four slopes are required for the example above. Normally, the input will cover the full 72 columns of the FORMAT field.

Capacity Input Cards if MALCAP = 1 (Figure 20)
NEWCAP Control Card (Figure 21)
Parallel Relief Alternative Cards if NEWCAP = 0
(Figures 22-24)
NUM Control Cards if NEWCAP = 0 (Figure 25)
INUM Control Card if NEWCAP = 0 (Figure 26)
NW SLIP, NW SLOP, NW DIAM if NEWCAP = 0 (Figure 26A)

2.1.5. Control Cards - End of Execution

Two such cards are used for each run--a remote card and an ENDJOB card. See Figures 27 and 28.

2.2 Discussion of Data Cards

2.2.1. Flow Factors Card

Flow factors for each category of land use in terms of gallons per acre per day are entered in a 7F 10.2 format (Figure 11). Factors are incorporated in the following order from left to right across the card.

1. Single Family Residential
2. Multi-Family Residential - Low Density
3. Multi-Family Residential - High Density
4. Commercial Land Use - Low Density
5. Commercial Land Use - High Density
6. Industrial Land Use
7. Institutional Land Use

There will be one Flow Factor Card per run.

2.2.2. Acres Cards

The acreage for a given minisystem by category of land use is entered in a 7F 7.2 format (see Figure 12). The order in which the acreage is entered corresponds to the order used for the flow factors above as follows:

1. Single Family Residential Acreage
2. Multi-Family - Low Density - Acreage
3. Multi-Family - High Density - Acreage
   and so forth through the Institutional Land Use Acreage.

There will be one "Acres" and for each minisystem in the flow network.

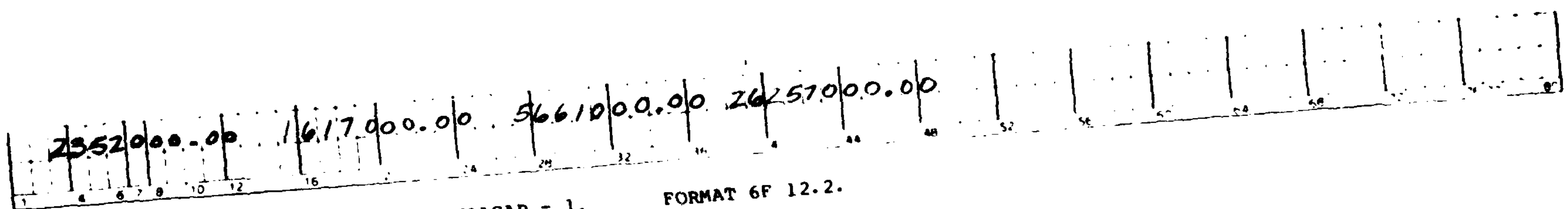


FIGURE 20 - CAPACITY INPUT CARD IF MALCAP = 1.   FORMAT 6F 12.2.

Note:

1. Only four pipe capacities are shown above. The FORMAT allows for up to six capacities per card.

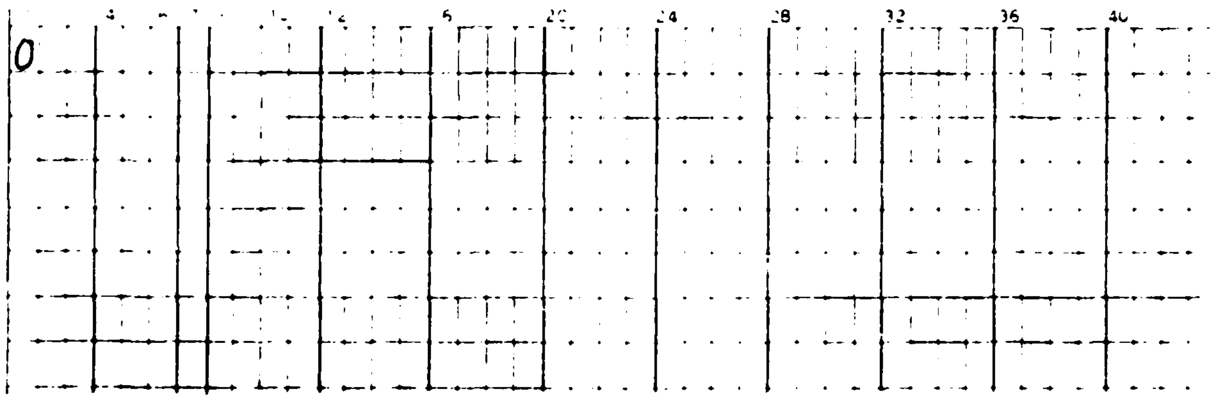


FIGURE 21 - NEWCAP CONTROL CARD. FORMAT I1.

Notes:

1. A zero in column one directs the computer to alter the existing capacity of one or more sewer pipes in the network.

2. A one in column one indicates to the computer that no sewer pipes will receive altered flow.

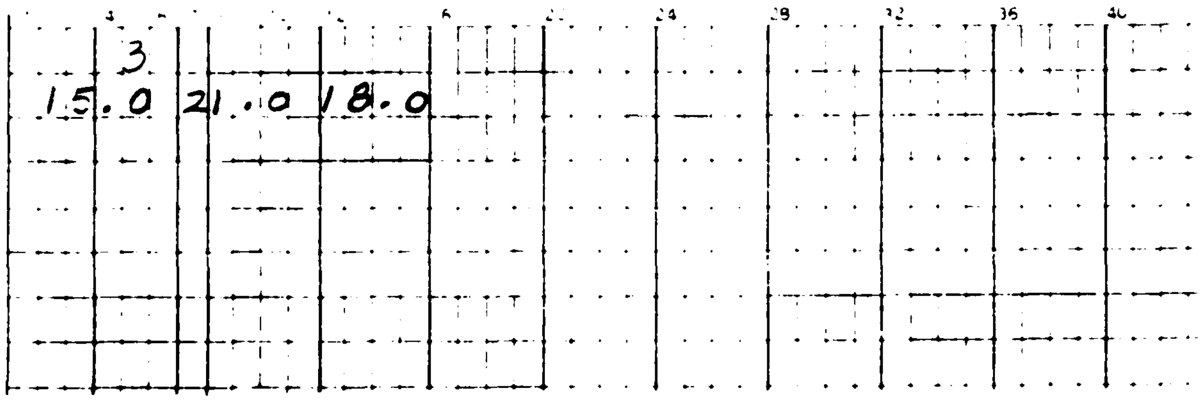


FIGURE 22 - NUMNEW AND DIAMETER INPUT TO ALTCAP
Subroutine NEWCAP = 0
FORMAT for NUMNEW is I5.
FORMAT for Diameter is 14F 5.1.

Notes:

1. NUMNEW gives the number of sewer lines in the system to receive altered capacity via the ALTCAP subroutine. Row 1 above is NUMNEW = 3.
2. The diameter input follows NUMNEW when NEWCAP = 0. Diameter is in inches and gives the size of pipes to be altered.

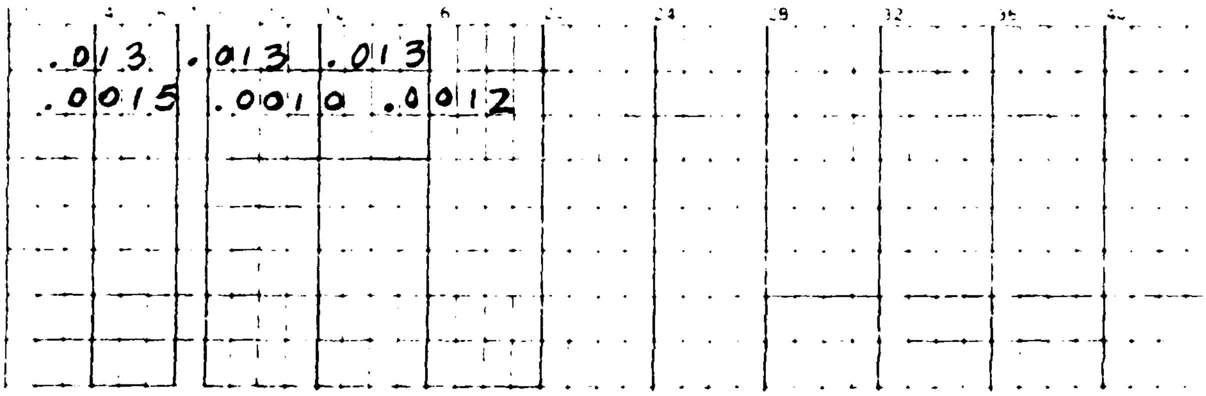


FIGURE 23 - ROUGHNESS AND SLOPE INPUT TO ALTCAP
Subroutine NEWCAP = 0
FORMAT for Roughness is 14F 5.3.
FORMAT for Slope is 12F 6.4.

Notes:

1. Roughness is Manning's number for pipes altered using ALTCAP. Row one above is the roughness input.
2. Slope is given in feet per thousand feet - Row 2 above.
3. Roughness and slope data follow diameter as inputs when NEWCAP = 0 in order.

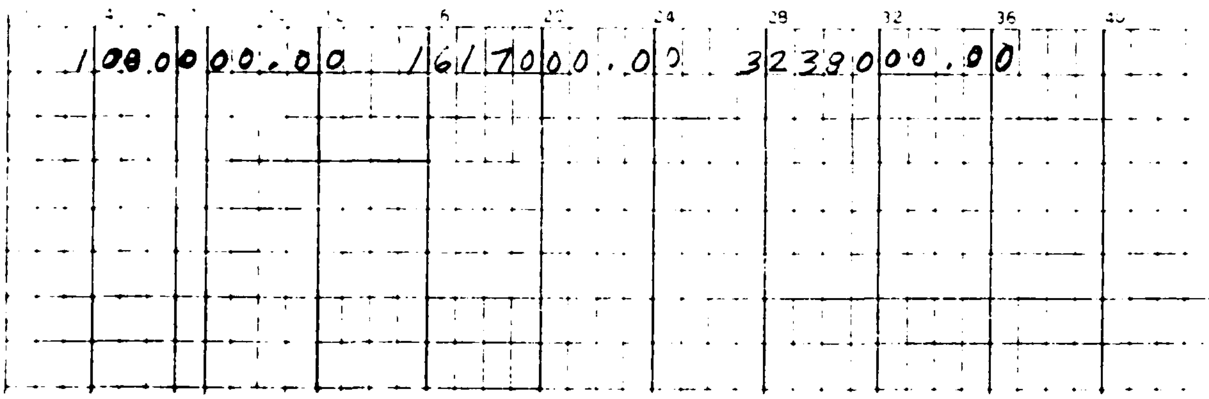


FIGURE 24 - ORICAP INPUT TO ALTCAP SUBROUTINE.
NEWCAP = 0.
Format is 6F 12.2.

Notes:

1. The ORICAP input gives the unaltered sewer line capacity of the minisystem receiving revised capacity using ALTCAP.
2. Units are gallons per day.

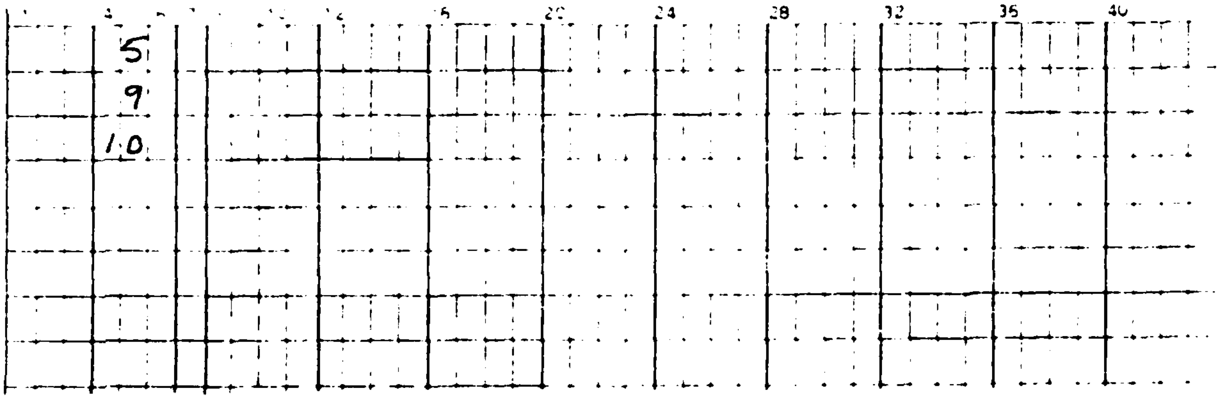


FIGURE 25 - TYPICAL EXAMPLES OF NUM CARDS. FORMAT I5.

Note:

The NUM cards advise the computer which pipes in the network have received altered capacity through the use of subroutine ALTCAP. The numbers above are the TOTFLO array element numbers of the minisystems receiving altered flow (Section 3 discusses the numbering procedure).

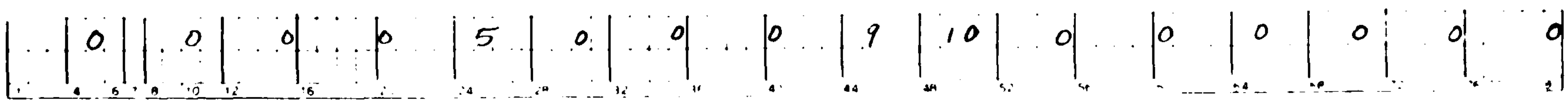


FIGURE 26 - TYPICAL INUM CONTROL CARD. FORMAT IS 16I5.

Note:

See Section 2.2.11. for an explanation of this card's usage.

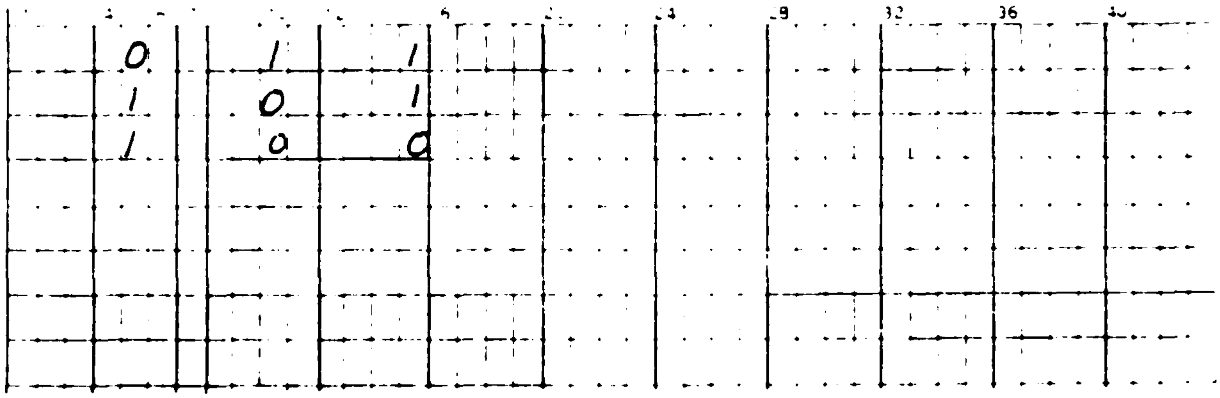


FIGURE 26A - NWSLIP, NWSLOP, NWDIAM CARDS. FORMAT 3I5.

Notes:

1. A zero or one in Column 5 indicates that sliplining was or was not accomplished to alter capacity respectively.
2. A zero or one in Column 10 indicates that slope adjustment was or was not accomplished to alter capacity respectively.
3. A zero in Column 15 indicates that a diameter change has been made to alter capacity either through installation of a parallel pipe or removal and replacement of existing pipe. A one indicates no change.
4. Example: The first of the three cards in Figure 26A indicates that the pipe was sliplined to alter capacity.

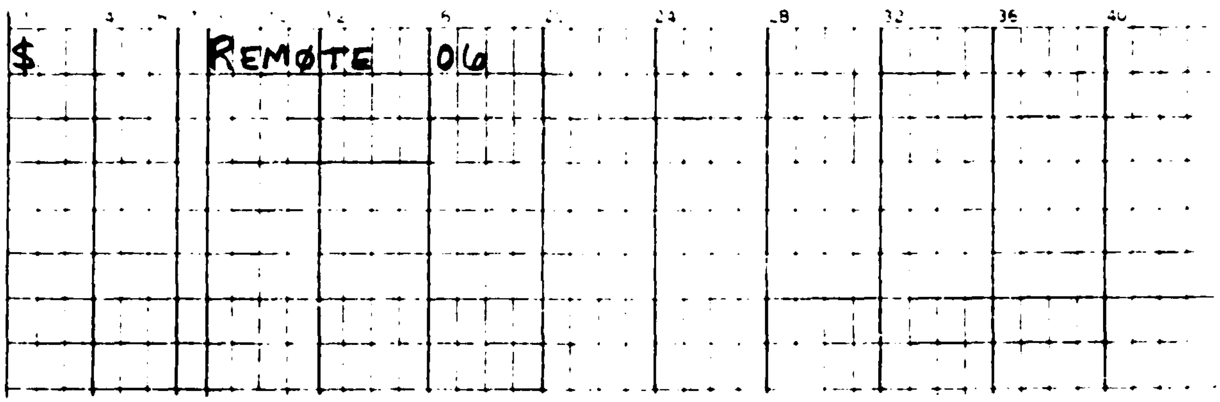


FIGURE 27 - REMOTE CONTROL CARD

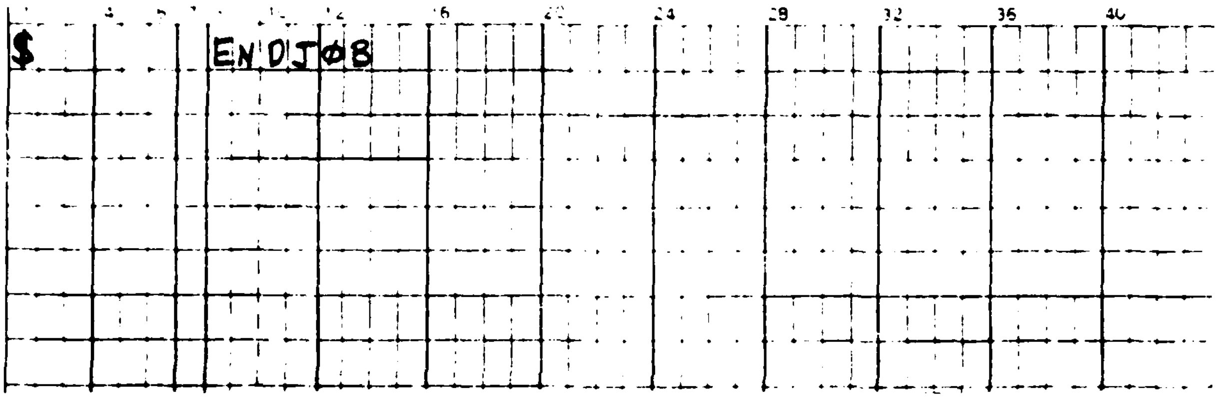


FIGURE 28 - END JOB CONTROL CARD

2.2.3. Pipe Cards

The pipe nomenclature for each pipe segment is entered in a 10A7 alphanumeric format - 10 pipe segments (minisystems) per card (Figure 13). There will be one pipe nomenclature assigned to each minisystem. For example, for a 400 minisystem network there will be 40 pipe cards.

2.2.4. Minisystem Cards

Minisystem designations are incorporated in a 10A5 format (Figure 14). Note that ten minisystem names per card are allowable. So for a 300 minisystem network 30 such cards would be required.

2.2.5. Network Flow Accumulation Cards (NFAC)

The cards allow the sanitary sewer flow to be accumulated from minisystem to minisystem. The NFAC describe to the computer the pipe segment layout being evaluated. One such card is required for each minisystem. NFAC format is 12I5 - (Figure 15). The first number on the card is the "TOTFLO array number" assigned to the minisystem. (Each minisystem is assigned a number which corresponds to its TOTFLO number.) This process will be described during the example problem formulation of Section 3. The second and third numbers are the CUMPIP and CUMNOD array numbers respectively for the minisystem in question. The next six numbers are pipe segments (TOTFLO elements) whose flows intersect the particular minisystem. The final three numbers represent upstream accumulated modal flows that will be routed through the minisystem in question. To simplify the preparation of NFAC it is recommended that the first four numbers on the cards be the same for each minisystem. The network cards are the most important data input to the program and will be covered in greater detail in Section 3.

2.2.6. MALCAP

This card is a control card that tells the computer if the capacities of the sanitary sewer lines in the system will be calculated in the program or calculated by hand and input directly. Format for MALCAP is I1. If MALCAP equals zero, the computer calls a subroutine (CAPCTY) and calculates the capacity of each pipe segment in the network. If MALCAP equals 1, the program expects the capacity input directly. One MALCAP card per run is required.

2.2.7. Data Cards for CAPCTY Subroutine

These cards are required only if MALCAP equals zero. When MALCAP equals zero, cards advising the computer of the diameter, slope and Manning number of each pipe in the network are

required. Diameter information is input first in a 14F 5.1 format. (If there are 420 minisystems to be analyzed, 30 diameter cards are required (420 divided by 14 equals 30)). Next, Manning's number is entered; format is 14F 5.3. Finally, slope information in terms of feet per 1,000 feet is input in a 12F 6.4 format. Examples of each of these cards appear as Figures 17 through 19.

2.2.8. Capacity Input

If MALCAP equals 1, then the capacity of each pipe in the network is entered at this point in the data stacking. Format is 6F 12.2. See Figure 20.

2.2.9. NEWCAP

This card is a control card that tells the computer if the capacities of any of the lines will be altered by 1) removal and replacement of existing lines, 2) slope adjustment, 3) slip lining, or 4) installation of a parallel line. Format is I1. If NEWCAP equals zero, then the computer calls a subroutine (ALTCAP) and alters the capacity of the line in question. If NEWCAP equals one, the program skips the ALTCAP subroutine and proceeds without changing any pipe capacities.

2.2.10. Data Cards for ALTCAP Subroutine

These cards are required only when NEWCAP equals zero. The NUMNEW card advises the computer how many lines will receive altered flow. Format is I5. Diameter, roughness, and slope information are input in 14F 5.1, 14F 5.3, and 12F 6.4 formats respectively as for the input to the CAPCTY subroutine. The original capacity of the minisystem being modified is next read into the machine using a 6F 12.2 format (Figures 22 through 24.)

2.2.11. Main Program Additional Data Input If NEWCAP = 0

When NEWCAP equals zero, a "NUM" card is used to give the TOTFLO array element number of the minisystem for which the ALTCAP subroutine has been used. One card is used for each minisystem receiving relief via ALTCAP. NUM allows the computer to substitute the modified capacity for the originally entered computer value. Format is I5.

SANSEW is designed to echo-check back to the engineer whenever ALTCAP has been used. In order to accomplish this check, an array called "INUM" is entered after NUM in the deckstacking whenever NEWCAP equals zero. INUM has as many elements as there are total minisystems in the network in a 16 I5 format. For example, if the 59th minisystem in the network has received a flow capacity change through ALTCAP, then the number "59" will appear as the 59th element in the INUM array. This input will be clarified further in the example problem.

For each minisystem utilizing ALTCAP, a NWSLIP, NWSLOP, NWDIAM card is the next item of data input to the program. Format is 3 I5. A zero in the first five columns of the card indicates that sliplining was accomplished to alter the capacity of the mini-system under review. Similarly, zeros in columns six to ten and ten to fifteen indicate that slope adjustment and pipe replacement respectively were accomplished. One's in the aforementioned columns mean that one or more of the three alternatives (sliplining, slope adjustment, or replacement) were not completed.

TABLE 1 - SUMMARY OF INPUT FOR SANSEW

Card Input	Format	Number of Cards	Figure	When Used
Identification	See Figure	1	1	Every Run
User Ident	See Figure	1	2	Every Run
Option FORTRAN	See Figure	1	3	Every Run
FORTRAN	See Figure	1	4	Every Run
Incode IBMEL	See Figure	1	5	Every Run
Main Program	See Figure	Varies	6 and 7	Every Run
Execute Card	See Figure	1	8	Every Run
Data Card	See Figure	1	9	Every Run
Limits Card	See Figure	1	10	Every Run
Flow Factors	7F 10.2	1	11	Every Run
Access Cards	7F 7.2	Equals No. of Minisystems	12	Every Run
Pipe Cards	10A 7.	No. of Minisystems Divided by 10	13	Every Run
Minisystems	10A 5.	No. of Minisystems Divided by 10	14	Every Run
Network Cards	12I 5.	Equals No. of Minisystems	15	Every Run
MALCAP	I1	1	16	Every Run
If MALCAP Equals Zero: CAPCTY Subroutine Input as Follows:				
Diameter	14F 5.1	Equals No. of Minisystems Divided by 14	17	Only if MALCAP = 0
Roughness	14F 5.3	Equals No. of Minisystems Divided by 14	18	Only if MALCAP = 0
Slope	12F 6.4	Equals No. of Minisystems Divided by 12	19	Only if MALCAP = 0
If MALCAP Equals One: Input Capacity of Pipe Segments	6F 12.2	Equals No. of Minisystems Divided by 6	20	Only if MALCAP = 1
NEWCAP	I1	1	20	Every Run
ALTCAP Subroutine Input as Follows:				
NUMNEW	I5	1	20	Only if NEWCAP = 0

Card Input	Format	Number of Cards	Figure	When Used
Diameter	14F 5.1	Equals No. of Pipes With Changed Capacity Divided by 14	21	Only if NEWCAP = 0
Roughness	14F 5.3	Equals No. of Pipes With Changed Capacity Divided By 14	22	Only if NEWCAP = 0
Slope	12F 6.4	Equals No. of Pipes With Changed Capacity Divided By 12	23	Only if NEWCAP = 0
Original Capacity	6F 12.2	Equals No. of Pipes with Changed Capacity Divided By 6	24	Only if NEWCAP = 0
NUM	I5	One Card for Each Minisystem Having Changed Capacity	25	Only if NEWCAP = 0
INUM	16I 5	Equals Number of Pipes with Changed Capacity Divided By 16	26	Only if NEWCAP = 0
NWSLIP, NWSLOP, NWDIAM	3I 5	Equals Number of Pipes with Changed Capacity	27	Only if NEWCAP = 0

3.0 ANALYSIS OF EXAMPLE SANITARY SEWER SYSTEM

To assist the user in understanding SANSEW, a hypothetical sanitary sewer system has been constructed and is illustrated in Figure 28A. This example system will be referenced throughout the following discussion.

For the sake of simplicity assume flow factors as follows:

Landuse Catagory	Flow Factor (GPAD)
Single-Family Residential	6,000
Multi-Family Residential - Low Density	15,000
Multi-Family Residential - High Density	20,000
Commercial Low Density	6,000
Commercial High Density	15,000
Industrial	6,000
Institutional	6,000

Given the sanitary sewer system, the following computations are desired:

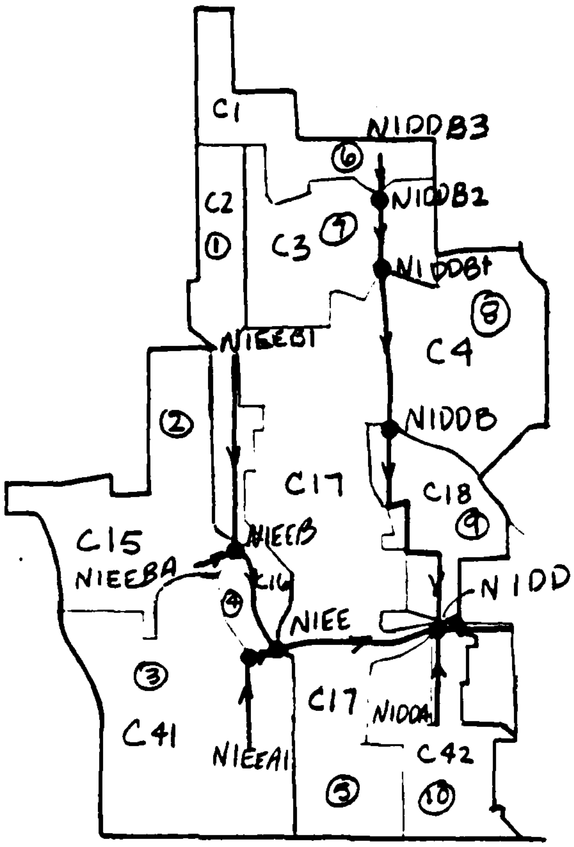
a. A flow projection for the year 2000.
b. An alternative evaluation to relieve deficient pipe segments projected for the network in "a".

3.1. Example Flow Projection

The basic mechanics used by SANSEW to project the flow from any minisystem involves the multiplication of the input flow factors times their corresponding acreage values. The total flow then generated within a specific minisystem is the summation of those values. The computer stores this total in an array called "TOTFLO" for usage later in the program.

The sequence in which the TOTFLO array is computed is critical. Every input data parameter during the flow projection must correspond to the TOTFLO sequence. For example, when the acreage values for minisystem C1 are entered into the card deck, the C1 acreage card must be the 6th one to appear since C1 bears the number "6" in the numbering sequence for the system. Similarly, when C1 appears on the minisystem input card, C1 will be the <u>sixth</u> identifier. More importantly, the sequence in which the TOTFLO array is established has a direct bearing upon how the accumulated flow through a minisystem will be calculated.

Turning to the problem at hand, note from Figure 28A that 10 minisystems are included in the hypothetical system. Normally, the minisystem names and pipe nomenclature will already have been



C41, etc. = Minisystem Names
N1EEA1, etc. = Pipe Nomenclature
1 = Minisystem Number in the TOTFLO Array
→ = Direction of Flow

FIGURE 28 - HYPOTHETICAL SANITARY SEWER SYSTEM EXAMPLE RUN - SANSEW

assigned by the time the flow projection is to be made. The planner's first step then is to assign sequential numbers to the minisystems. It is recommended that these numbers be made to correspond to the direction of flow, that is, as the flow accumulates the numbers get larger. Note that in the example network the flow is from left to right, in general. Laterals flow towards the major trunk line NIEE-NIDD. As emphasized previously, the numbering sequence is very important in the accumulation of flow. The flow from the various segments through a particular minisystem is stored in an array called "CUMNOD" which will be described in Section 3.1.1.3.1.

3.1.1. Data Input

3.1.1.1. Control Cards

If the control cards are not yet done, prepare them as shown in Figures 1 through 5, 8 through 10, and 28 through 29. Insert cards 1 through 5 at the beginning of the main program deck and the remainder, in order, at the end of the deck.

3.1.1.2. Main Program Cards

The following cards must be added (Figure 29).

1. Dimension cards for arrays that are used in the program:

Array Name	(Dimension)	Figure
CUMNOD	(12)	29
INUM	(10)	29
FLO	(7)	29
ACRES	(7,10)	29
PROFLO	(7,10)	29
TOTFLO	(11)	29
PIPE	(10)	29
CAP	(10)	29
CUMPIP	(10)	29
DIFFLO	(10)	29
MINSYS	(10)	29
DEFICT	(10)	29
MINDEF	(10)	29
PIPDEF	(10)	29
REVCAP	(10)	29
RELIEF	(10)	29

Note that the arrays CUMNOD and TOTFLO are dimensioned slightly higher than the number of minisystems in the network. At least one element in each of CUMNOD and TOTFLO must be reserved for a zero value. Main program dimension cards appear at the front of the program. See program listing, Appendix A.

```
      DIMENSION CUMNOD(12),INUM(10)                                        5
      DIMENSION FLO(7),ACRES(7,10),PROFLO(7,10),TOTFLO(11),PIPE(10),CAP(   6
     *10),CUMPIP(10),DIFFLO(10),RELIEF(10)                                 7
      DIMENSION MINSYS(10),DEFFLO(10),MINDEF(10),PIPDEF(10),REVCAP(10)
      CUMNOD(12)=0.00                                                     38
      TOTFLO(11)=0.00                                                     39
      DO 40 J=1,10
      DO 46 J=1,10
      DO 47 J=1,10
      DO 77 M=1,10
      DO 225 J=1,10
      IF(ISN.LT.10) GO TO 58
   79 FORMAT(1X,'PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000'//)
   80 FORMAT(1X,'FLOW FACTORS FOR THE YEAR 2000 ARE SHOWN BELOW'/)         65
```

FIGURE 29 - MAIN PROGRAM CARDS EXAMPLE SYSTEM

2. Add "zero" cards. TOTFLO (11) = 0.00 and CUMNOD (12) = 0.00. Note in Appendix A where these cards go.
3. There are 5 "Do" loops in the main program for which the indices must be provided. For the flow projection, these indices must correspond to the number of minisystems under evaluation. "Do" loops are located at cards 17, 25, 33, 55, and 81.
4. Card 46 reads as shown in Figure 29. The number to the right of "L.T." must equal the number of minisystems.
5. Cards 63 and 65 are adjusted to reflect the year in which the flow projection is to be made. For purposes of this example assume the year 2000.

3.1.1.3. Data to be Entered

After the intermediate control cards mentioned in Section 3.1.1.1. above, the data cards in the order described in previous sections can be prepared. See the coding sheets - Figures 30 through 36 for examples, the network input will be explained in detail below.

3.1.1.3.1. Network Flow Accumulation Cards

The network cards allow for flow to be accumulated throughout the sanitary sewer system. Also, the planner can use the network cards to split flow and for analysis of non-parallel relief systems.

The network cards work as follows. Each minisystem has one such card on which are specified in order 1) the card number, ISN, 2) the CUMPIP array number, IN, 3) the CUMNOD array number, NF, 4) up to six TOTFLO elements which are upstream from the minisystem in question, and 5) up to three codes which are upstream from the minisystem.

Before the network accumulation begins, the total projected flow through each minisystem has already been computed. The CUMPIP array is established as follows:

$$\begin{aligned} \text{CUMPIP(IN)} = {} & \text{TOTFLO (NPIPE1)} + \text{TOTFLO (NPIPE2)} + \\ & \text{TOTFLO (NPIPE3)} + \text{TOTFLO (NPIPE4)} + \\ & \text{TOTFLO (NPIPE5)} + \text{TOTFLO (NPIPE6)} \end{aligned} \qquad \text{(Equation 1)}$$

The "NPIPE" numbers of Equation 1 are input on the network cards. In this way, the planner can have the computer sum the flow from up to 6 minisystems. Unfortunately, most flow networks contain minisystems with more than six upstream pipe segments. To handle this situation the CUMNOD array stores the accumulated flow for each minisystem as follows:

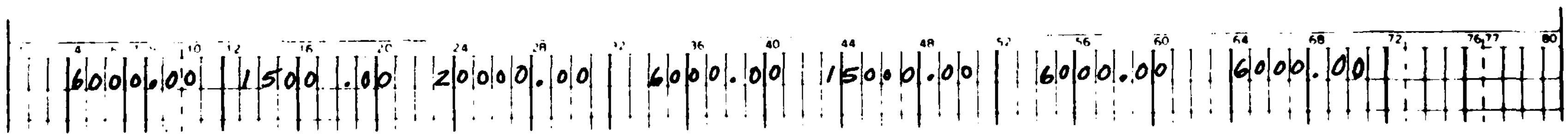


FIGURE 30 - FLOW FACTOR INPUT. FORMAT 7F10.2.

LANDUSE ACREAGES

Minisystem ↓	SINGLE	MULTI-LO	MULTI-HI	COMM-LO	COMM-HI	INDUSTRY	INSTITUTIONAL
C2	70.45	0.00	5.20	24.68	0.00	0.00	2.09
C15	148.46	0.00	23.45	6.97	0.00	0.00	8.08
C41	145.25	3.04	86.21	19.01	0.00	27.39	0.00
C16	5.49	0.00	7.92	21.29	0.00	3.05	0.00
C17	236.68	0.00	17.85	50.03	0.00	12.89	0.00
C1	70.29	3.84	7.25	18.17	0.00	0.00	0.00
C3	138.77	0.00	3.19	0.00	0.00	0.00	0.00
C4	218.04	3.26	13.87	8.25	6.20	10.97	0.00
C18	5.02	0.00	8.29	34.42	0.00	23.25	23.37
C42	76.34	0.00	0.00	46.12	0.00	0.00	0.00

FIGURE 31 - ACREAGE INPUT. FORMAT 7F7.2.

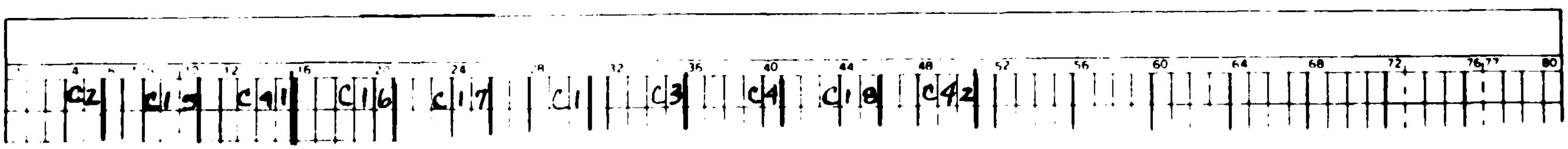


FIGURE 32 - MINISYSTEM INPUT. FORMAT 10A5.

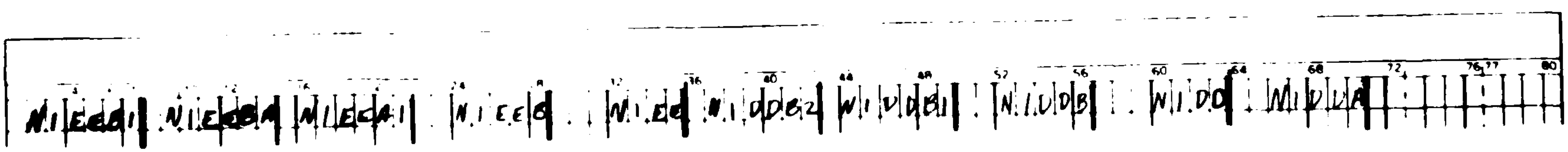


FIGURE 33 - PIPE INPUT - NOMENCLATURE. FORMAT 10A7.

Subsystem	ISN Data Set No.	IN Cumuluative Array #	NF Cummed Array #	TOTFLO (PIPE) ELEMENTS: NPIPE 1	NPIPE 2	NPIPE 3	NPIPE 4	NPIPE 5	NUPSTRM	UPSTREAM NODES: NODUP 1	NODUP 2	NODUP 3
C2	1	1	1	1	11	11	11	11	11	12	12	12
C15	2	2	2	2	11	11	11	11	11	12	12	12
C41	3	3	3	3	11	11	11	11	11	12	12	12
C16	4	4	4	4	11	11	11	11	11	1	2	12
C7	5	5	5	5	11	11	11	11	11	4	3	12
C1	6	6	6	6	11	11	11	11	11	12	12	12
C3	7	7	7	7	11	11	11	11	11	6	12	12
C4	8	8	8	8	11	11	11	11	11	7	12	12
C18	9	9	9	9	11	11	11	11	11	8	12	12
C42	10	10	10	10	11	11	11	11	11	12	12	12

FIGURE 34 - NETWORK INPUT. FORMAT 12I5.

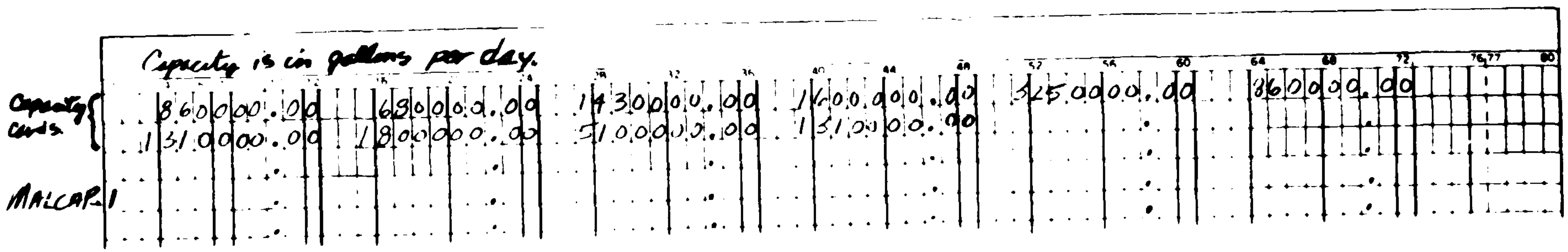


FIGURE 35 - MALCAP EQUALS 1.

FORMAT: DIAMETER= 4F5.1, ROUGHNESS= MF5.3, SLOPE= 12F6.4
MALCAP = I1

MALCAP	0									
Diameter	12.0	12.0	15.0	15.0	24.0	12.0	15.0	18.0	24.0	15.0
Roughness	.013	.013	.013	.013	.013	.013	.013	.013	.013	.013
Slope	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010

FIGURE 36 - CAPACITY INPUT IF MALCAP = 0

CUMNOD (NF) = CUMPIP(IN) + CUMNOD(NODNO1) + CUMNOD (NODNO2) + CUMNOD (NODNO3)
(Equation 2)

The "NODNO" numbers 1 through 3 are input on the network cards. In this way the accumulated flow of up to three upstream nodes can be totaled through a given element.

The inclusion of a "zero" TOTFLO element and a "zero" CUMNOD element allows for the case in which a minisystem does not have as many as six upstream pipe segments or three upstream nodes. The zero array numbers were discussed earlier in this section - TOTFLO (11) = 0.00 and CUMNOD (12) = 0.00. Use of TOTFLO (11) and CUMNOD (12) is illustrated below.

With the above explanation in mind, the network cards for the example system will be completed. Refer to Figure 34. The first card is the input for minisystem C2. C2 will be the first pipe segment to have flow stored in both the CUMPIP array and the CUMNOD array. Hence, IS, IN, and NF all equal 1. Since the only minisystem contributing flow to C2 is C2, NPIPE1 equals 1 and is so coded on Figure 34. Note that 1 is C1's TOTFLO array element number. NPIPE's 2 through 6 are entered as 11 to indicate zero additional flow. NOD NO.1 through 3 are shown as 12, since no upstream nodal flows pass through C2. Similarly, the network cards are created for minisystems C15 and C41. For C16 flow from C2 and C15 must be added to the sewage generated by C16 alone. Accordingly, in Figure 34 a "1" and a "2" are entered as NODNO1 and NODNO2, respectively. A perfectly acceptable alternative method for flow accumulation here would be to enter a "1" and a "2" under NPIPE2 and NPIPE3, respectively and to change the values for each of NODNO1 and NODNO2 to 12. For C18 only NPIPE1 and NODNO1 are needed entries to establish all the flow through the minisystem. NPIPE1 equals 9, which tells the computer to add the flow contribution from C18. NODNO1 is 8 which is CUMNOD(8) which in turn contains the flows from C1, C3, and C4.

The preparation of the network cards is the most important step in preparing the input data to the computer. The method is simple and very flexible; but, the planner must remember the following:

1. He is just entering numbers that will be used to develop the flow summations of Equations 1 and 2.
2. The numbering sequence previously used to order data becomes especially important during the network formulation. The planner must know which TOTFLO element number contains the flow for each minisystem. Also, numbers entered on the cards must represent flow calculations that the computer has already

performed. For example, all the flows from individual minisystems have been computed and stored in the TOTFLO array before the flow accumulation begins. Accordingly, any NPIPE number from the system can be used. On the other hand, the CUMNOD array values are not determined until the network calculations are done. Only CUMNOD numbers that have been previously calculated can therefore be used on the flow cards. To illustrate, supposing the planner had intended to accumulate the flows from C1, C3, and C4 as CUMNOD (10) instead of CUMNOD (8). But C18 which is number 9 in the accumulation still must carry C1, C3, and C4. If the planner attempts to add CUMNOD (10), the element that now contains C1, C3, and C4, by using NODNO1 = 10 he will not accumulate the flow from C1, C3, and C4. CUMNOD (10) has not yet been calculated. A zero is stored in each CUMNOD element until it is computed. A simple way to avoid the above problem is to always ensure that the NODNO's used are lower than or equal to the ISN numbers. If the flow is accumulated in sequence (1, 2, 3 etc. as in the example section), then the engineer is assured that any NODNO he uses will have already been computed.

3.1.1.3.2. Capacity Input

Two computer runs of the example system will be made. One run will have the capacity figures entered; the second will have the capacity calculated. Note that MALCAP equals "1" in the first case, "0" in the second. Data cards for each run are Figures 35 and 36.

For the input capacity numbers of Figure 35, the following capacities were used:

TOTFLO #	Minisystem	Capacity (Gallons Per Day)
1	C2	860,000
2	C15	680,000
3	C41	1,430,000
4	C16	1,600,000
5	C17	3,250,000
6	C1	860,000
7	C3	1,310,000
8	C4	1,800,000
9	C18	5,100,000
10	C42	1,310,000

For the computer run when MALCAP = 0 the following input data was used:

TOTFLO #	Minisystem	Diameter	Roughness	Slope
1	C2	12	.013	.001
2	C15	12	.013	.001
3	C41	15	.013	.001
4	C16	15	.013	.001
5	C17	24	.013	.001
6	C1	12	.013	.001
7	C3	15	.013	.001
8	C4	18	.013	.001
9	C18	24	.013	.001
10	C42	15	.013	.001

3.1.1.3.3. NEWCAP

For the flow projection NEWCAP = 1. ALTCAP, NUM, INUM, and NWSLIP, NWSLOP, NWDIAM inputs are not needed.

3.1.2. Flow Projection Output

Flow projection output for each of the two runs is given as Appendix B for the case of input capacity and Appendix C for the case of computed capacity. The two runs create different results because the slope values for Appendix C's output were all assumed to be .001 for the sake of simplicity.

Note that the program creates a listing of deficient pipe segments that gives the minisystem, pipe nomenclature, deficiency amount, and minimum parallel line relief size required to handle the excess flow. The relief line is designed assuming construction at standard grade in accordance with the City of Houston regulations.

3.2. Alternative Evaluation

Using the flow projection of Appendix B this Section will illustrate an alternative scheme to relieve excess flow in the example network.

3.2.1. Non-Parallel Relief Input

The sewer line for minisystem C17 (See Appendix B) is deficient by 4,299,060 gallons per day. To relieve some of this flow a non-parallel relief line, shown dashed on Figure 37, is proposed. In order to evaluate nonparallel lines a "dummy" mini-system must be created. This dummy will carry the sewage from C2 and C15 to node NIDD, thus reducing the flow through C17. Certain adjustments to the program are required for this scheme.

First of all, the main program statements on Figure 29 must be changed. Also, the input of Figures 31 through 35 must be expanded to include the new pipe segment. The changes necessary

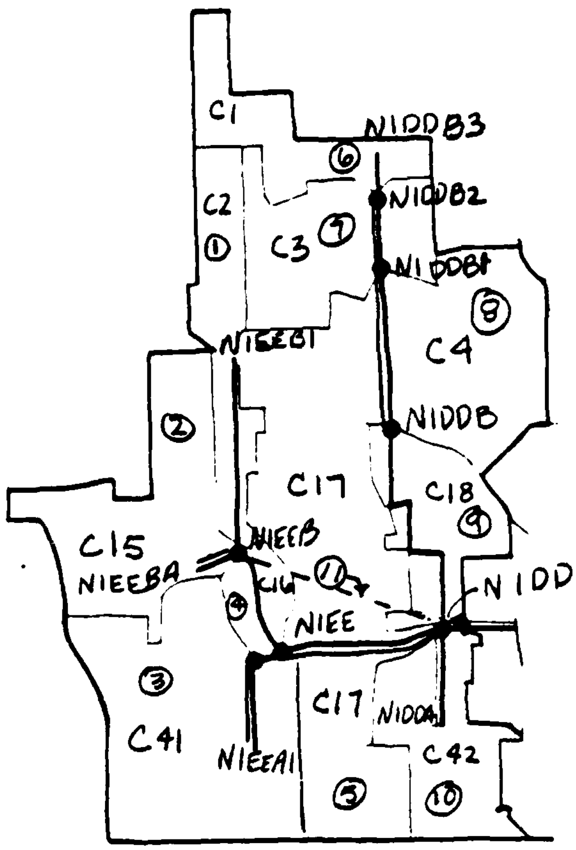


FIGURE 37 - ALTERNATIVE EVALUATION

are shown in Figures 38 through 43. Note the added main program statement that defines the TOTFLO for the non-parallel line. This number can either be hand calculated and added to the program as shown or computer calculated. Since a given alternative will probably only by evaluated once, time can sometimes be saved by hand calculating the flow through the new sewer pipe as demonstrated here:

$$\text{TOTFLO (11)} = \underset{\text{TOTFLO (1)}}{687{,}320} + \underset{\text{TOTFLO (2)}}{1{,}450{,}060}$$

$$= 2{,}137{,}380$$

Now when the network cards are prepared the non-parallel relief line will carry 2,137,380 gallons per day.

Another way to handle the relief pipe would be to set TOTFLO (11) = TOTFLO (1) + TOTFLO (2). This approach has the same affect as the hand calculation above.

An 18-inch line having a capacity of 2,352,000 gallons per day is proposed. The capacity value could have been calculated by the computer as was done for the flow projection of Appendix C.

The network must also be revised. Refer to Figure 42. The eleventh minisystem, that is, the relief line, now carries C2 and C15 while C16 does not.

3.2.2. Parallel Relief Input

The non-parallel line discussed in Section 3.2.1. will not completely relieve the flow through C17. 2,161,680 gallons per day will be relieved via parallel lines. An 18-inch line will be tried to illustrate use of the ALTCAP subroutine.

Relief for minisystems C15, C41, C3 and C4 will be by parallel line as discussed in Section 3.2.2.2. below. By inspection C16's deficiency is relieved by the non-parallel sewer line.

3.2.2.1. ALTCAP Input for Minisystem C17

Figure 44 depicts the input required to use ALTCAP. First of all, the dimension statements in the subroutine must be adjusted. Since only one pipe capacity will be changed using ALTCAP, the dimension of each array in the subroutine is "1". Format and explanation of each remaining input on Figure 44 have already been discussed.

```
DIMENSION CUMNOD(12),INUM(11)
DIMENSION FLO(7),ACRES(7,11),PROFLO(7,11),TOTFLO(12),PIPE(11),CAPC
*(11),CUMHIP(11),DIFFLO(11),RELIEF(11)
DIMENSION MINSYS(11),DEFICT(11),MINDEF(11),PIPDEF(11),KEYCAP(11)
CUMNOD(12)=0.00                                                  3
TOTFLO(12)=0.00                                                 39
TOTFLO(11)=2137380.00                                          39A
DO 40 J=1,11                                                    17
DO 46 J=1,11                                                    25
DO 47 J=1,11                                                    33
DO 77 M=1,11                                                    55
DO 225 J=1,11                                                   81
IF(ISN.LT.11)GO TO 58                                           46
```

Notes:

1. The card numbers 63 and 65 covering the year of Flow projection do not change, since the year 2000 will again be used.

2. Card 39A gives the Flow thru the non-parallel relief line.

FIGURE 38 - MAIN PROGRAM CHANGES FOR NON-PARALLEL RELIEF

Minisystem	LANDUSE ACREAGES SINGLE	MULTI-LO	MULTI-HI	COMM-LO	COMM-HI	INDUSTRY	INSTITUTIONAL
C2	70.45	0.00	5.20	24.63	0.00	0.00	2.09
C15	143.46	0.00	23.45	6.97	0.00	0.00	8.08
C41	145.25	3.04	96.21	19.01	0.00	27.39	0.00
C16	5.49	0.00	7.12	21.24	0.00	3.05	0.00
C17	226.63	0.00	17.35	50.00	0.00	12.89	0.00
C1	70.29	3.94	7.25	19.17	0.00	0.00	0.00
C3	133.77	0.00	3.19	0.00	0.00	0.00	0.00
C4	219.04	3.26	12.37	8.25	6.20	10.97	0.00
C18	5.02	0.00	8.29	24.42	0.00	23.25	3.37
C42	76.34	0.00	10.00	46.12	0.00	0.00	0.00
Dummy	1.10	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE 39 - NON-PARALLEL RELIEF ADDITION

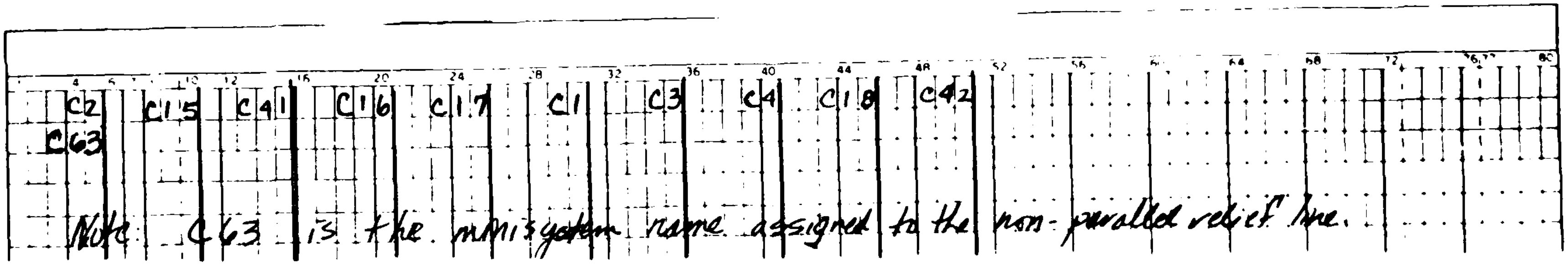


FIGURE 40 - NON-PARALLEL RELIEF ADDITION

N1EEB1 N1EEBA N1EEA1 N1EEB N1EE N1DDE2 N1DDB1 N1DDB N1DD N1DDA

DUMMY1

Note: "DUMMY 1" is the pipe nomenclature assigned to the Non-parallel relief system.

FIGURE 41 - NON-PARALLEL RELIEF ADDITION

Manhp-	ISN Data Set No.	IN CUMVIP ARRAY #	NF CUMNOD ARRAY #	TØTFLØ (PIPE) ELEMENTS					UPSTREAM NØDES			
C2	1	1	1	1	12	12	12	12	12	12	12	12
C15	2	2	2	2	12	12	12	12	12	12	12	12
C41	3	3	3	3	12	12	12	12	12	12	12	12
C16	4	4	4	4	12	12	12	12	12	12	12	12
C17	5	5	5	5	4	3	12	12	12	12	12	12
C1	6	6	6	6	12	12	12	12	12	12	12	12
C3	7	7	7	7	12	12	12	12	12	6	12	12
C4	8	8	8	8	12	12	12	12	12	7	12	12
C18	9	9	9	9	12	12	12	12	12	9	12	12
C42	10	10	10	10	12	12	12	12	12	12	12	12
C63	11	11	11	11	12	12	12	12	12	12	12	12

FIGURE 42 - NON-PARALLEL RELIEF ADDITION

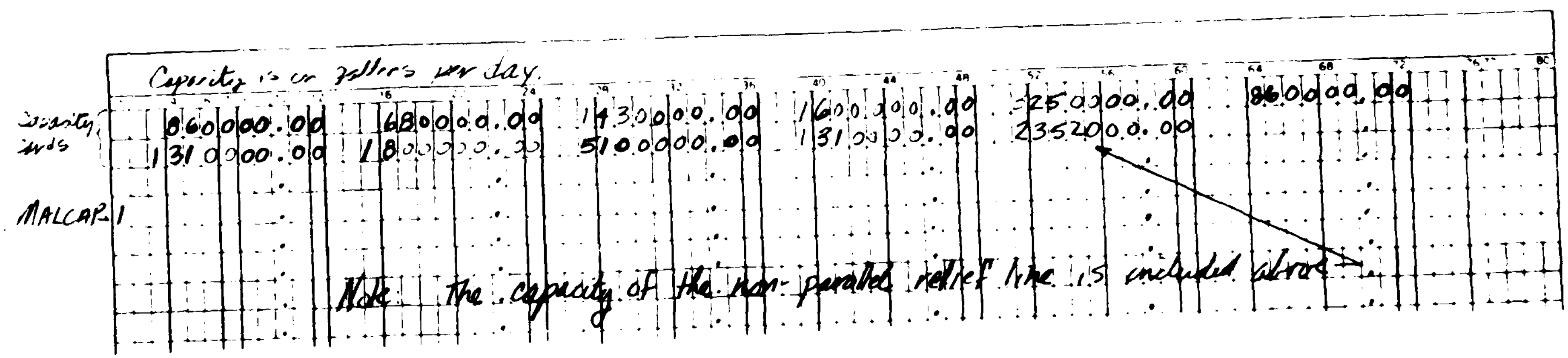


FIGURE 43 - MALCAP EQUALS 1. NON-PARALLEL RELIEF ADDITION

Array Dimension	DIMENSIØN REVCAP(1), AREA(1), WETPER(1), HYRAD(1), K(1), Q(1), DIAM(1), S 157
	*LØPE(1), RØUGHN(1), VEL1(1), VEL2(1), VELCTY(1), FS(1), ØRICAP(1). 158
NUMNEW	1
DIAM	18.0
ROUGHN	.013
SLOPE	.0012
ØRICAP	3250000.00
NEWCAP	0
NUM	5
INUM	0 0 0 0 5 0 0 0 0 0
NUSLIP, NUSLOP, NUMRUN	1 1 0

FIGURE 44 - ALTCAP INPUT FOR PARALLEL RELIEF LINE

3.2.2.2. Parallel Relief for Minisystem C15, C41, C3, and C4

The parallel relief lines for these minisystems will be as recommended in Column 4 of the output as follows:

Minisystem	Parallel Relief Line (In.)
C15	12
C14	15
C3	12
C4	18

These line sizes are developed using Manning's equation with n equal .013 and slope equal standard grade as specified by the City of Houston regulations governing the construction of main and lateral sanitary sewers.

3.2.3. Comments on Alternative Imput

The input data required for non-parallel relief lines and for use of ALTCAP can be rather extensive for more complex systems. However, the effort is necessary in order to see the downstream results of such alternatives. The ALTCAP subroutine for parallel pipes should only be used when the Manning number does not equal .013 or when the standard grade slope will not be used, since the program automatically designs parallel lines to relieve excess flow.

3.2.4. Results of Alternative Evaluation

Appendix D gives the results of the alternative process. C15, C41, C3, and C4 are shown as being deficient; however, as noted above these lines will be relieved using the parallel line size recommended on the output. No other minisystems are shown as having excess flow indicating that the relief scheme developed in this section would be satisfactory.

4.0 SPECIAL CASE OF SPLIT FLOWS

Occasionally, it is necessary to split flows within the network as might be the case at a pumping station. In order to split flows additional TOTFLO elements are added to the network as will be demonstrated in the example below.

Refer to Figure 45. In this system, the flow is to be split at point N1B before entering minisystems A2 and A3. For purposes of this example, also assume 90 percent of the flow goes to N1D and 10 percent goes to N1C. Finally, assume that the accumulated flow for A1 is stored in CUMNOD (1). At this point the planner creates three additional FORTRAN statements for entry into the main program as follows (See Figure 46 for coding):

```
CUMNOD (1) = TOTFLO (1)
TOTFLO (4) = -(.1 * CUMNOD (1))
TOTFLO (5) = -(.9 * CUMNOD (1))
```

These statements appear after statement number 39. Since TOTFLO's (4) and (5) are functions of CUMNOD (1), CUMNOD (1) must be defined as a separate FORTRAN statement before values can be assigned to TOTFLO's (4) and (5).

For this example, TOTFLO (6) = 0.00 and CUMNOD (4) = 0.00. Now in order to split the flow, the network flow accumulation cards for the system are prepared as shown in Figure 47. Recalling equations (1) and (2) of Section 3, the planner should readily see that the flow would be split as desired.

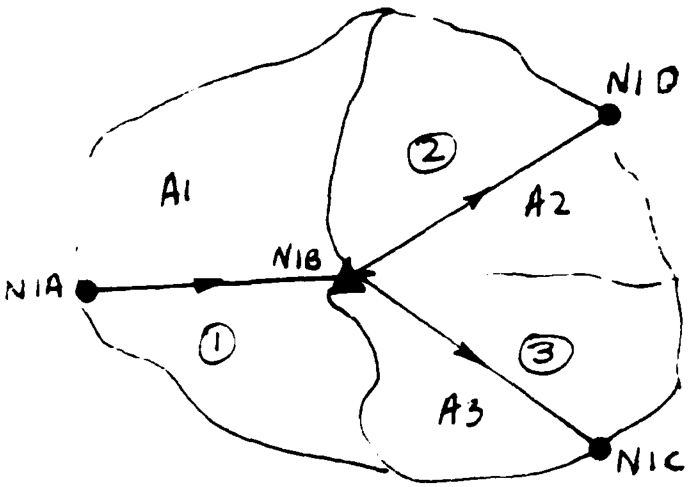


FIGURE 45 - SPLIT FLOW EXAMPLE

```
      CUMNØD(1)=TØTFLØ(1)                                              39A
      TØTFLØ(4)=-(.1*CUMNØD(1))                                        39B
      TØTFLØ(5)=-(.9*CUMNØD(1))                                        39C
```

FIGURE 46 - CODING FOR FORTRAN STATEMENTS REQUIRED TO SPLIT FLOW

ISN Data Set No.	IN CUMVIP ARRAY #	NF CUMNOD ARRAY #	TØTFLØ (PIPE) ELEMENTS						UPSTREAM NØDES		
1	1	1	1	6	6	6	6	6	4	4	4
2	2	2	2	4	6	6	6	6	1	4	4
3	3	3	3	5	6	6	6	6	1	4	4

FIGURE 47 - SPLIT FLOW EXAMPLE

5.0 USING SANSEW TO DESIGN NEW SEWER SYSTEMS

SANSEW can be used to design new sanitary sewer systems. Although no example of a design will be given in this manual the method would be as follows:

1. Layout the proposed network for the area for which the system is desired.
2. Establish minisystem boundaries.
3. Obtain areas by category of land use within each minisystem.
4. Decide upon flow factors.
5. Run SANSEW with zero capacity shown for each minisystem.

The output listing of pertinent pipes would show every minisystem with excess flow; but, the fourth column under "MIN RELIEF SIZE (IN)" would indicate the size pipe needed to handle the flow. These pipes constitute a preliminary design for the sewer system. In the event that standard grade would not be used or that the Manning number would differ from .013 the design might have to be altered somewhat and the program re-run.

APPENDIX A - PROGRAM LISTING

```
C
C PROGRAM TO COMPUTE PROJECTED FLOWS AND COMPARE TO CAPACITY
C
C INPUT STATEMENTS
     DIMENSION CUMNOD(12),INUM(10),RELIEF(10)
     DIMENSION FLO(7),ACRES(7,10),PROFLO(7,10),TOTFLO(11),PIPE(10),CAP(
    *10),CUMPIP(10),DIFFLO(10)
     DIMENSION MINSYS(10),DEFICT(10),BINDEF(10),PIPDEF(10),REVCAP(10)
     READ(5,10)FLO
  10 FORMAT(7F10.2)
     READ(5,20)ACRES
  20 FORMAT(7F7.2)
     READ(5,21)PIPE
  21 FORMAT(10A7)
     READ(5,27)MINSYS
  27 FORMAT(10A5)
C COMPUTE PROJECTED FLOWS BY LAND USE TYPE SURROUNDING A PIPE SEGMENT
     DO 40 J=1,10
     DO 30 I=1,7
  30 PROFLO(I,J)=FLO(I)*ACRES(I,J)
  40 CONTINUE
C
C COMPUTE TOTAL FLOW IN THE PIPE SEGMENT
C
     TOTFLO(J)=0
     DO 46 J=1,10
     DO 45 I=1,7
  45 TOTFLO(J)=TOTFLO(J)+PROFLO(I,J)
  46  CONTINUE
C
C COMPUTE TOTAL FLOW THROUGHOUT THE SYSTEM
C
     SYSFLO=0
     DO 47 J=1,10
  47 SYSFLO=SYSFLO+TOTFLO(J)
C
C ACCUMULATE FLOW FROM SEGMENT TO SEGMENT THROUGH THE SYSTEM
C
     CUMNOD(12)=0.00
     TOTFLO(11)=0.00
  58 READ(5,59)ISN,IN,NF,NPIPE1,NPIPE2,NPIPE3,NPIPE4,NPIPE5,NPIPE6,NODN
    *01,NODNO2,NODNO3
  59 FORMAT(12I5)
     CUMPIP(IN)=TOTFLO(NPIPE1)+TOTFLO(NPIPE2)+TOTFLO(NPIPE3)+TOTFLO(NPI
    *PE4)+TOTFLO(NPIPE5)+TOTFLO(NPIPE6)
     CUMNOD(NF)=CUMPIP(IN)+CUMNOD(NODNO1)+CUMNOD(NODNO2)+CUMNOD(NODNO3)
     IF(ISN.LT.11)GO TO 58
     READ(5,60)MALCAP
  60 FORMAT(I1)
     IF(MALCAP)62,61,62
  61 CALL CAPCTY(CAP)
     IF(MALCAP.EQ.0)GO TO 1000
```

```
      62 READ(5,63)CAP                                                      48
      63 FORMAT(6F11.2)                                                     49
C                                                                          49A
C        STATEMENTS FOR ALTCAP SUBROUTINE TO MODIFY FLOW FOLLOW            49B
C                                                                          49C
    1000 READ(5,64)NEWCAP                                                  49D
      64 FORMAT(I1)                                                        49E
         IF(NEWCAP)76,65,76                                                49F
      65 CALL ALTCAP(REVCAP,NUMNEW)                                        49G
         INEWCP=0                                                          49H
      66 READ(5,67)NUM                                                     49I
      67 FORMAT(I5)                                                        49J
         INEWCP=INEWCP+1                                                   49K
         CAP(NUM)=REVCAP(INEWCP)                                           49L
         IF(INEWCP.LT.NUMNEW) GO TO 66                                     49M
C                                                                           50
         READ(5,70)(NUM                                                    50A
      70 FORMAT(16I5)                                                      50B
C                                                                           51
C     COMPUTE TOTAL CAPACITY OF SYSTEM                                      52
C                                                                           53
      76 TOTCAP=0                                                           54
         DO 77 M=1,10                                                       55
      77 TOTCAP=CAP(M)+TOTCAP                                               56
C                                                                           57
C     OUTPUT STATEMENTS AND COMPARISON OF PROJECTED FLOWS TO CAPACITY       58
C                                                                           59
         WRITE(6,78)                                                        60
      78 FORMAT(1X,'NORTHSIDE SANITARY SEWER SYSTEM MASTER PLAN'//)         61
         WRITE(6,79)                                                        62
      79 FORMAT(1X,'PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000'//) 63
         WRITE(6,80)                                                        64
      80 FORMAT(1X,'FLOW FACTORS FOR THE YEAR 2000 ARE SHOWN BELOW:'/)      65
         WRITE(6,90)                                                        66
      90 FORMAT(1X,'UNITS ARE GALLONS PER ACRE PER DAY (GPAD).'//)          67
         WRITE(6,100)                                                       68
     100 FORMAT(1X,1X,'SING FAM',2X,'MULTI-LO',2X,'MULTI-HI',2X,'COMM-LO',2 69
        *X,' COMM-HI',2X,'INDUSTRY',2X,'INSTITUT'/)                         70
C                                                                           71
         WRITE(6,120)FLO(1),FLO(2),FLO(3),FLO(4),FLO(5),FLO(6),FLO(7)       72
     120 FORMAT(1X,F7.1,4X,F7.1,4X,F7.1,2X,F7.1,3X,F7.1,2X,F7.1,3X,F7.1///) 73
         WRITE(6,130)                                                       74
     130 FORMAT(1X,'LAND USES ARE ASSIGNED NUMBER CODES AS FOLLOWS:'/)      75
         WRITE(6,135)                                                       76
     135 FORMAT(1X,'1=SINGLE FAMILY,2=MULTI-FAMILY LOW DENSITY,3=MULTI-FAMI 77
        *LY-HIGH DENSI-'/1X,'TY,4=COMMERCIAL-LOW DENSITY,5=COMMERCIAL-HIGH  78
        *DENSITY,6=INDUSTRIAL,'/1X,'7=INSTITUTIONAL'////)                   79
         K=0                                                               80A
         L=0                                                               80B
         M=0                                                               80C
         N=0                                                               80D
         IS=0                                                              80E
```

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```
      NDEF=0                                                              80F
      DO 225 J=1,10                                                       81
      IF(NEWCAP.EQ.1)GO TO 148                                            81AAAA
      IF(J.EQ.INUM(J))GO TO 141                                           81AAA
      IF(J.NE.INUM(J))GO TO 143                                           81BBB
  141 READ(5,142)NWSLIP,NWSLOP,NWDIAM                                     81CCC
  142 FORMAT(3I5)                                                         81DDD
  143 IS=IS+1                                                             81A
      WRITE(6,144)J                                                       81AA
  144 FORMAT(1X,I4/)                                                      81AB
      WRITE(6,145)MINSYS(IS)                                              81B
  145 FORMAT(1X,'MINISYSTEM',1X,A5)                                       81C
      K=K+1                                                               82
      WRITE(6,150)PIPE(K)                                                 83
  150 FORMAT(1X,'PIPE NOMENCLATURE',1X,A7//)                              84
      WRITE(6,160)                                                        85
  160 FORMAT(1X,'LANDUSE CODE',2X,'ACREAGE',2X,'PROJECTED FLOW (GPD)'/)   86
      DO 166 I=1,7                                                        87
      WRITE(6,165)I,ACRES(I,J),PROFLO(I,J)                                88
  165 FORMAT(1X,7X,I2,5X,F7.2,4X,F11.2//)                                 89
  166 CONTINUE                                                            89A
      N=N+1                                                               90
      WRITE(6,170)TOTFLO(N)                                               91
  170 FORMAT(1X,2X,'TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SE  92
     *GMENT ABOVE IS'/1X,F12.2,'GPD.'//)                                  93
      L=L+1                                                               94
      WRITE(6,180)CUMNOD(L)                                               95
  180 FORMAT(1X,2X,'ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS:',1X,F12.2/)  96
      M=M+1                                                               97
      WRITE(6,190)CAP(M)                                                  98
  190 FORMAT(1X,2X,'THE CAPACITY (GPD) OF THE ABOVE PIPE IS:',1X,F12.2//  99
     *)                                                                   99A
C                                                                         100
C  COMPARISON OF PROJECTED FLOW TO CAPACITY                               101
C                                                                         102
      DIFFLO(N)=CAP(M)-CUMNOD(L)                                          103
      IF (DIFFLO(N))200,212,212                                           104
  200 WRITE(6,201)DIFFLO(N)                                               105
  201 FORMAT(1X,'THE CAPACITY OF THE PIPE IS EXCEEDED BY-',F12.2,'=-GALL  106
     *ONS PER DAY.'/////)                                                 107
      IF(NEWCAP.EQ.1)GO TO 211                                            107AAA
      IF(J.EQ.INUM(J))GO TO 202                                           107BBB
      IF (J.NE.INUM(J))GO TO 211                                          107CCC
  202 IF(NWSLIP.EQ.1) GO TO 207                                           107AA
      WRITE(6,206)                                                        107BB
  206 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLIPLINING."/////)   107CC
  207 IF(NWSLOP.EQ.1) GO TO 209                                           107DD
      WRITE(6,208)                                                        107EE
  208 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLOPE ADJUSTMENT."/  107FF
     */////)                                                              107GG
  209 IF(NWDIAM.EQ.1) GO TO 211                                           107HH
      WRITE(6,210)                                                        107II
```

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```
      210 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY INCREASED DIAMETER.     107JJ
     *"//////)                                                                    107KK
      211 NDEF=NDEF+1                                                             107A
          DEFICT(NDEF)=DIFFLO(N)                                                  107B
          MINDEF(NDEF)=MINSYS(IS)                                                 107C
          PIPDEF(NDEF)=PIPE(K)                                                    107D
          GO TO 225                                                               108
      212 WRITE(6,215)DIFFLO(N)                                                   109
      215 FORMAT(1X,'THIS PIPE IS ADEQUATE BY',1X,F12.2,1X,'GPD.'//////)          110
          IF(NEWCAP.EQ.1)GO TO 229                                                110A
          IF(J.EQ.INUM(J))GO TO 216                                               110B
          IF (J.NE.INUM(J))GO TO 225                                              110C
      216 IF(NWSLIP.EQ.1) GO TO 219                                               110F
          WRITE(6,218)                                                            110G
      218 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLIPLINING."/////)       110H
      219 IF(NWSLOP.EQ.1) GO TO 221                                               110I
          WRITE(6,220)                                                            110J
      220 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLOPE ADJUSTMENT."/      110K
     *////)                                                                       110L
      221 IF(NWDIAM.EQ.1) GO TO 225                                               110M
          WRITE(6,222)                                                            110N
      222 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY INCREASED DIAMETER.     110O
     *"//////)                                                                    110P
      225 CONTINUE                                                                111
          WRITE(6,230)SYSFLO                                                      112
      230 FORMAT(1X,'THE TOTAL PROJECTED FLOW THROUGHOUT THE SYSTEM IS',1X,      113
     *F12.2,1X,'GALLONS',/,1X,'PER DAY.'/)                                        114
          WRITE(6,240)TOTCAP                                                      115
      240 FORMAT(1X,'THE TOTAL CAPACITY OF THE SYSTEM IS',1X,F12.2,1X,'GALLO     116
     *NS'/1X,'PER DAY.'///)                                                       117
          IF(DEFICT(1))250,355,355                                                118
      250 WRITE(6,252)                                                            119
      252 FORMAT(1X,'A LISTING OF PIPES WITH INADEQUATE CAPACITY TO HANDLE P     120
     *ROJECTED AC-'/1X,'CUMULATED FLOW FOLLOWS.  THE MINIMUM SIZE PARALL         121
     *EL PIPE REQUIRED TO RE-'/1X,'LIEVE EXCESS FLOW IS REFLECTED IN THE         122
     * FOURTH COLUMN BELOW.  THIS PIPE  '/1X,'SIZE IS OBTAINED FROM MANN         123
     *ING S EQUATION WITH N=.013 AND SLOPE=STAN-'/1X,'DARD GRADE AS SPEC         124
     *IFIED IN THE ADDENDUM TO E-14, CITY OF HOUSTON SPECI-'/1X,'FICATI          125
     *ON FOR SEWER CONSTRUCTION-PAGE 4.'///)                                      125AA
          WRITE(6,254)                                                            125A
      254 FORMAT(1X,'MINISYSTEM',9X,'PIPE NOMENCLATURE',5X,'DEFICIENCY(GPD)'     126
     *,5X,'MIN RELIEF SIZE(IN)'///)                                               127
          DO 350 I=1,NDEF                                                         128
          IF(DEFICT(I).LT.-1080000)GO TO 255                                      129
          RELIEF(I)=12.0                                                          130
          GO TO 340                                                               131
      255 IF(DEFICT(I).LT.-1617000)GO TO 260                                      132
          RELIEF(I)=15.0                                                          133
          GO TO 340                                                               134
      260 IF(DEFICT(I).LT.-2352000)GO TO 265                                      135
          RELIEF(I)=18.0                                                          136
          GC TO 340                                                               137
```

```
  265 IF(DEFICT(I).LT.-4185000)GO TO 270                                  138
      RELIEF(I)=24.0                                                      139
      GO TO 340                                                           140
  270 IF(DEFICT(I).LT.-5601000)GO TO 273                                  140A
      RELIEF(I)=27.0                                                      140B
      GO TO 340                                                           140C
  273 IF(DEFICT(I).LT.-7408000)GO TO 275                                  141
      RELIEF(I)=30.0                                                      142
      GO TO 340                                                           143
  275 IF(DEFICT(I).LT.-12192000)GO TO 280                                 144
      RELIEF(I)=36.0                                                      145
      GO TO 340                                                           146
  280 IF(DEFICT(I).LT.-18891000)GO TO 285                                 147
      RELIEF(I)=42.0                                                      148
      GO TO 340                                                           149
  285 IF(DEFICT(I).LT.-26257000)GO TO 287                                 149A
      RELIEF(I)=48.0                                                      149B
      GO TO 340                                                           149C
  287 IF(DEFICT(I).LT.-39946000)GO TO 290                                 150
      RELIEF(I)=54.0                                                      151
      GO TO 340                                                           152
  290 IF(DEFICT(I).LT.-37636000)GO TO 295                                 153
      RELIEF(I)=60.0                                                      154
      GO TO 340                                                           155
  295 IF(DEFICT(I).LT.-54739000)GO TO 300                                 156
      RELIEF(I)=72.0                                                      157
      GO TO 340                                                           158
  300 IF(DEFICT(I).LT.-58888000)GO TO 305                                 159
      RELIEF(I)=84.0                                                      160
      GO TO 340                                                           161
  305 IF(DEFICT(I).LT.-70178000)GO TO 310                                 162
      RELIEF(I)=90.0                                                      163
      GO TO 340                                                           164
  310 IF(DEFICT(I).LT.-118116000)GO TO 315                                165
      RELIEF(I)=108.0                                                     166
      GO TO 340                                                           167
  315 IF(DEFICT(I).LT.-151134000)GO TO 320                                168
      RELIEF(I)=120.0                                                     169
      GO TO 340                                                           170
  320 IF(DEFICT(I).LT.-198868000)GO TO 325                                171
      RELIEF(I)=132.0                                                     172
      GO TO 340                                                           173
  325 IF(DEFICT(I).LT.-249758000)GO TO 330                                174
  330 RELIEF(I)=144.0                                                     175
      GO TO 340                                                           176
  340 WRITE(6,345)MINDEF(I),PIPDEF(I),DEFICT(I),RELIEF(I)                 177
  345 FORMAT(1X,2X,A5,11X,A7,12X,F12.2,17X,F5.1///)                       178
  350 CONTINUE                                                            179
      GO TO 365                                                           180
  355 WRITE(6,360)                                                        181
  360 FORMAT(1X,'ALL PIPES EVALUATED IN THE ABOVE NETWORK ARE ADEQUATE T  182
     *O HANDLE PRO-',/1X,'JECTED ACCUMULATED FLOW.',////)                 183
```

```
        261         365 STOP                                   184
        262             END                                    185
*****N    7 MEMORY EXPANDED, USE SLIMITS OR CORE= OPTION FOR NEXT RUN
```

```
      SUBROUTINE CAPCTY(CAP)                                              133A
      DIMENSION CAP(10),AREA(10),WETPER(10),HYRAD(10),R(10),S(10),DIAM(1  134
     *0),SLOPE(10),ROUGHN(10),VEL1(10),VEL2(10),VELCTY(10),CFS(10)        135
      READ(5,300)DIAM                                                     136
  300 FORMAT(14F5.1)                                                      137
      READ(5,310)ROUGHN                                                   138
  310 FORMAT(14F5.3)                                                      139
      READ(5,320)SLOPE                                                    140
  320 FORMAT(12F6.4)                                                      141
      PIE=3.1459                                                          142
      DO 340 M=1,10                                                       143
      AREA(M)=((PIE*(DIAM(M)**2))/4.00)/144.00                            144
      WETPER(M)=PIE*DIAM(M)/12.00                                         145
      HYRAD(M)=AREA(M)/WETPER(M)                                          146
      R(M)=HYRAD(M)**.6666667                                             147
      S(M)=SLOPE(M)**.5                                                   148
      VEL1(M)=1.486/ROUGHN(M)                                             149
      VEL2(M)=R(M)*S(M)                                                   150
      VELCTY(M)=VEL1(M)*VEL2(M)                                           151
      CFS(M)=AREA(M)*VELCTY(M)                                            152
      CAP(M)=CFS(M)*7.48*86400.00                                         152A
  340 CONTINUE                                                            153
      RETURN                                                              154
      END                                                                 155
```

```
      SUBROUTINE ALTCAP(REVCAP,NUMNEW)                                   156
      DIMENSION REVCAP (21),AREA(21),WETPER(21),HYRAD(21),R(21),S(21),DI 157
     *AM(21),SLOPE(21),ROUGHN(21),VEL1(21),VEL2(21),VELCTY(21),CFS(21),O 158
     *RICAP(21)                                                          158A
      READ(5,400)NUMNEW                                                  159
  400 FORMAT(I5)                                                         160
      READ(5,410)DIAM                                                    161
  410 FORMAT(14F5.1)                                                     162
      READ(5,420)ROUGHN                                                  163
  420 FORMAT(14F5.3)                                                     164
      READ(5,430)SLOPE                                                   165
  430 FORMAT(12F6.4)                                                     166
      READ(5,435)ORICAP                                                  166A
  435 FORMAT(6F11.2)                                                     166B
      PIE=3.1459                                                         167
      DO 440 M=1,NUMNEW                                                  168
      AREA(M)=((PIE*(DIAM(M)**2))/4.00)/144.00                           169
      WETPER(M)=PIE*DIAM(M)/12.00                                        170
      HYRAD(M)=AREA(M)/WETPER(M)                                         171
      R(M)=HYRAD(M)**.6666667                                            172
      S(M)=SLOPE(M)**.5                                                  173
      VEL1(M)=1.486/ROUGHN(M)                                            174
      VEL2(M)=R(M)*S(M)                                                  175
      VELCTY(M)=VEL1(M)*VEL2(M)                                          176
      CFS(M)=AREA(M)*VELCTY(M)                                           177
      REVCAP(M)=(CFS(M)*7.48*86400)*ORICAP(M)                            178
  440 CONTINUE                                                           179
      RETURN                                                             180
      END                                                                181
```

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APPENDIX B - FLOW PROJECTION WITH CAPACITY INPUT

SNURB = 85093, ACTIVITY # = 08, , REPORT CODE = 06, RECORD COUNT = 000353

NORTHSIDE SANITARY SEWER SYSTEM MASTER PLAN

PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000

FLOW FACTORS FOR THE YEAR 2000 ARE SHOWN BELOW;
UNITS ARE GALLONS PER ACRE PER DAY (GPAD),

SING FAM	MULTI-LO	MULTI-HI	COMM-LO	COMM-HI	INDUSTRY	INSTITUT
6000.0	15000.0	20000.0	6000.0	15000.0	6000.0	6000.0

LAND USES ARE ASSIGNED NUMBER CODES AS FOLLOWS=
1=SINGLE FAMILY,2=MULTI-FAMILY LOW DENSITY,3=MULTI-FAMILY-HIGH DENSI-
TY,4=COMMERCIAL-LOW DENSITY,5=COMMERCIAL-HIGH DENSITY,6=INDUSTRIAL,
7=INSTITUTIONAL

1
MINISYSTEM C8
PIPE NOMENCLATURE N1EE01

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	70.45	422700.00
2	0.	0.
3	9.20	184000.00
4	24.68	148080.00
5	0.	0.
6	0.	0.
7	2.09	12540.00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
687320.00GPD,

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 687320.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 860000.00

THIS PIPE IS ADEQUATE BY 172680.00 GPD.

2
MINISYSTEM C15
PIPE NOMENCLATURE N1EE0A

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	148.46	890759.99
2	0.	0.
3	23.45	469000.00

4	6.97	41820.00
5	0.	0.
6	0.	0.
7	8.08	48480.00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
1450040.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 1450040.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 680000.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY= -770040.00--GALLONS PER DAY.

3
MINISYSTEM C41
PIPE NOMENCLATURE N1BBA1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	145.25	871500.00
2	3.04	45600.00
3	86.21	1724200.00
4	19.01	114060.00
5	0.	0.
6	27.39	164340.00
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
2919700.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 2919700.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1430000.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY= -1489700.00--GALLONS PER DAY.

4
MINISYSTEM C16
PIPE NOMENCLATURE N1BEB

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	5.49	32940.00
2	0.	0.
3	7.92	158400.00

4	21,29	127740,00
5	0,	0,
6	3,05	18300,00
9	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
337880.00GPD,

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 2474760.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1600000,00

THE CAPACITY OF THE PIPE IS EXCEEDED BY= -874760.00--GALLONS PER DAY.

5
MINISYSTEM C17
PIPE NOMENCLATURE N188

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	236,68	1420080,00
2	0,	0,
3	17,85	397600,00
4	50,03	300180,00
5	0,	0,
6	12,89	77340,00
9	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
2194800.00GPD,

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 7549060.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 3250000.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY= -4299060.00--GALLONS PER DAY.

6
MINISYSTEM C1
PIPE NOMENCLATURE N10002

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	70,28	421680,00
2	3,04	97600,00
3	7,25	145000,00

4	18.17	109020.00
5	0.	0.
6	0.	0.
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
733300.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 733300.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 860000.00

THIS PIPE IS ADEQUATE BY 126700.00 GPD.

7
MINISYSTEM C3
PIPE NOMENCLATURE N1DDB1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	138.77	832620.00
2	0.	0.
3	3.19	63800.00
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
896420.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 1629720.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1310000.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -319720.00--GALLONS PER DAY.

8
MINISYSTEM C4
PIPE NOMENCLATURE N1DDB

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	218.04	1308240.00
2	3.26	48900.00
3	13.87	277400.00

4	8,25	49500,00
5	6,20	93000,00
6	10,97	65820,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
1082860.00GPD,

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 3478580,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1800000,00

THE CAPACITY OF THE PIPE IS EXCEEDED BY= -1672580.00*-GALLONS PER DAY,

9
MINISYSTEM C18
PIPE NOMENCLATURE N1DB

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	5,02	30120,00
2	0,	0,
3	8,29	165800,00
4	34,42	206520,00
5	0,	0,
6	23,25	139500,00
7	23,37	140220,00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
682160.00GPD,

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 4154740,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 5100000,00

THIS PIPE IS ADEQUATE BY 945260.00 GPD,

10
MINISYSTEM C48
PIPE NOMENCLATURE N1DDA

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	76,34	458040,00
2	0,	0,
3	0,	0,

4	46.12	276720.00
5	0.	0.
6	0.	0.
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS 734760.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 734760.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1310000.00

THIS PIPE IS ADEQUATE BY 575240.00 GPD.

THE TOTAL PROJECTED FLOW THROUGHOUT THE SYSTEM IS 12438560.00 GALLONS PER DAY.
THE TOTAL CAPACITY OF THE SYSTEM IS 18200000.00 GALLONS PER DAY.

A LISTING OF PIPES WITH INADEQUATE CAPACITY TO HANDLE PROJECTED ACCUMULATED FLOW FOLLOWS. THE MINIMUM SIZE PARALLEL PIPE REQUIRED TO RELIEVE EXCESS FLOW IS REFLECTED IN THE FOURTH COLUMN BELOW. THIS PIPE SIZE IS OBTAINED FROM MANNING S EQUATION WITH N=.013 AND SLOPE=STANDARD GRADE AS SPECIFIED IN THE ADDENDUM TO G-14, CITY OF HOUSTON SPECIFICATI ON FOR SEWER CONSTRUCTION.PAGE 4.

MINISYSTEM	PIPE NOMENCLATURE	DEFICIENCY(GPD)	MIN RELIEF SIZE(IN)
C15	N1EEBA	-770060.00	12.0
C43	N1EEA1	-1489700.00	15.0
C18	N1EEB	-874760.00	12.0
C17	N1EE	-4299060.00	27.0
C8	N1DDB1	-319720.00	12.0
C8	N1DDB	-1672580.00	18.0

APPENDIX C - FLOW PROJECTION WITH CAPACITY COMPUTER CALCULATED

SNUMH = H5002, ACTIVITY # = 02, , REPORT CODE = 06, RECORD COUNT = 000356

NORTHSIDE SANITARY SEWER SYSTEM MASTER PLAN

PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000

FLOW FACTORS FOR THE YEAR 2000 ARE SHOWN BELOW;
UNITS ARE GALLONS PER ACRE PER DAY (GPAD),

SING FAM	MULTI-LO	MULTI-HI	COMM-LO	COMM-HI	INDUSTRY	INSTITUT
6000,0	15000,0	20000,0	6000,0	15000,0	6000,0	6000,0

LAND USES ARE ASSIGNED NUMBER CODES AS FOLLOWS=
1=SINGLE FAMILY,2=MULTI-FAMILY LOW DENSITY,3=MULTI-FAMILY-HIGH DENSI-
TY,4=COMMERCIAL-LOW DENSITY,5=COMMERCIAL-HIGH DENSITY,6=INDUSTRIAL,
7=INSTITUTIONAL

1
MINISYSTEM C2
PIPE NOMENCLATURE N1EEB1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	70,45	422700,00
2	0,	0,
3	5,20	104000,00
4	24,68	148080,00
5	0,	0,
6	0,	0,
7	2,09	12540,00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
687320.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 687320,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 729125,65

THIS PIPE IS ADEQUATE BY 41805,65 GPD,

2
MINISYSTEM C15
PIPE NOMENCLATURE N1EEBA

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	148,45	890759,99
2	0,	0,
3	23,45	469000,00

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4	6,97	41820,00
5	0,	0,
6	0,	0,
7	8,08	48480,00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
1450060.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 1450060,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 729125,65

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -720934,35--GALLONS PER DAY.

3
MINISYSTEM C41
PIPE NOMENCLATURE N1EEA1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	145,25	871500,00
2	3,04	45600,00
3	86,21	1724200,00
4	19,01	114060,00
5	0,	0,
6	27,39	164340,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
2919700.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 2919700,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1321992,77

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -1597707,23--GALLONS PER DAY.

4
MINISYSTEM C16
PIPE NOMENCLATURE N1EEB

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	5,49	32940,00
2	0,	0,
3	7,92	158400,00

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4	21,29	127740,00
5	0,	0,
6	3,05	18300,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS 337380,00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 2474760,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1321992,77

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -1152767,23--GALLONS PER DAY,

5
MINISYSTEM C17
PIPE NOMENCLATURE N1EE

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	236,68	1420080,00
2	0,	0,
3	17,85	357000,00
4	50,03	300180,00
5	0,	0,
6	12,89	77340,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS 2194800,00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 7549060,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 4629659,38

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -2919400,63--GALLONS PER DAY,

6
MINISYSTEM C1
PIPE NOMENCLATURE N10062

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	70,28	421680,00
2	[illegible],84	57600,00
3	7,25	145000,00

```
        4        18.17       109820.00

        5         0.             0.

        6         0.             0.

        7         0.             0.

  TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
   733300.00GPD.

  ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS:     733300.00
  THE CAPACITY (GPD) OF THE ABOVE PIPE IS:     729125.65

THE CAPACITY OF THE PIPE IS EXCEEDED BY-    -4174.35*-GALLONS PER DAY.



    7
MINISYSTEM      C3
PIPE NOMENCLATURE   N1DDB1

LANDUSE CODE  ACREAGE  PROJECTED FLOW (GPD)
        1      138.77      832820.00

        2         0.             0.

        3        3.19       63800.00

        4         0.             0.

        5         0.             0.

        6         0.             0.

        7         0.             0.

  TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
   896420.00GPD.

  ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS:    1629720.00
  THE CAPACITY (GPD) OF THE ABOVE PIPE IS:    1321992.77

THE CAPACITY OF THE PIPE IS EXCEEDED BY-  -307727.23*-GALLONS PER DAY.



    8
MINISYSTEM      C4
PIPE NOMENCLATURE    N1DDB

LANDUSE CODE  ACREAGE  PROJECTED FLOW (GPD)
        1      218.84     1313240.00

        2        3.26       48900.00

        3       13.87      277400.00
```

```
      4         8,25       49900,00

      5         6,20       93000,00

      6        10,97       65820,00

      7         0,             0,

  TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
  3842860,00GPD,

  ACCUMULATED FLOW (GPD) OF ABCVE PIPE IS!   3472580,00
  THE CAPACITY (GPD) OF THE ABCVE PIPE IS!   2149706,03

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -1322873,97--GALLONS PER DAY,



   9
MINISYSTEM   C18
PIPE NOMENCLATURE    N1DD

LANDUSE CODE  ACREAGE  PROJECTED FLOW (GPD)
      1         5,02       30120,00

      2         0,             0,

      3         8,29      165800,00

      4        34,42      206520,00

      5         0,             0,

      6        23,25      139500,00

      7        23,37      140220,00

  TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
   682160,00GPD,

  ACCUMULATED FLOW (GPD) OF ABCVE PIPE IS!   4154740,00
  THE CAPACITY (GPD) OF THE ABCVE PIPE IS!   4629659,38

THIS PIPE IS ADEQUATE BY    474919,38 GPD,



  10
MINISYSTEM   C42
PIPE NOMENCLATURE    N1DDA

LANDUSE CODE  ACREAGE  PROJECTED FLOW (GPD)
      1        76,34      458040,00

      2         0,             0,

      3         0,             0,
```

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4	46.12	276720,00
5	0.	0.
6	0.	0.
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
734760.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 734760.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1321992,77

THIS PIPE IS ADEQUATE BY 587232,77 GPD.

THE TOTAL PROJECTED FLOW THROUGHOUT THE SYSTEM IS 12438560,00 GALLONS PER DAY.
THE TOTAL CAPACITY OF THE SYSTEM IS 18884372,75 GALLONS PER DAY.

A LISTING OF PIPES WITH INADEQUATE CAPACITY TO HANDLE PROJECTED ACCUMULATED FLOW FOLLOWS. THE MINIMUM SIZE PARALLEL PIPE REQUIRED TO RELIEVE EXCESS FLOW IS REFLECTED IN THE FOURTH COLUMN BELOW. THIS PIPE SIZE IS OBTAINED FROM MANNING S EQUATION WITH N=.013 AND SLOPE=STANDARD GRADE AS SPECIFIED IN THE ADDENDUM TO L-14, CITY OF HOUSTON SPECIFICATION FOR SEWER CONSTRUCTION-PAGE 4.

MINISYSTEM	PIPE NOMENCLATURE	DEFICIENCY(GPD)	MIN RELIEF SIZE(IN)
C15	N1EEBA	-720934,35	12.0
C41	N1EEA1	-1597707,23	15.0
C16	N1EEB	-1152767,23	15.0
C17	N1EE	-2919400,63	24.0
C1	N1DDB2	-4174,35	12.0
C3	N1DDB1	-307727,23	12.0
C4	N1DDB	-1342873,97	15.0

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APPENDIX D - ALTERNATIVE EVALUATION

```
C
C  PROGRAM TO COMPUTE PROJECTED FLOWS AND COMPARE TO CAPACITY
C
C  INPUT STATEMENTS
      DIMENSION CUMNOD(12),INUM(11)
      DIMENSION FLO(7),ACRES(7,11),PROFLO(7,11),TOTFLO(12),PIPE(11),CAP(
     *11),CUMPIP(11),DIFFLO(11),RELIEF(11)
      DIMENSION MINSYS(11),DEFICT(11),MINDEF(11),PIPDEF(11),REVCAP(11)
      READ(5,10)FLO
   10 FORMAT(7F10.2)
      READ(5,20)ACRES
   20 FORMAT(7F7.2)
      READ(5,21)PIPE
   21 FORMAT(10A7)
      READ(5,27)MINSYS
   27 FORMAT(10A5)
C  COMPUTE PROJECTED FLOWS BY LAND USE TYPE SURROUNDING A PIPE SEGMENT
      DO 40 J=1,11
      DO 30 I=1,7
   30 PROFLO(I,J)=FLO(I)*ACRES(I,J)
   40 CONTINUE
C
C  COMPUTE TOTAL FLOW IN THE PIPE SEGMENT
C
      TOTFLO(J)=0
      DO 46 J=1,11
      DO 45 I=1,7
   45 TOTFLO(J)=TOTFLO(J)+PROFLO(I,J)
   46  CONTINUE
C
C  COMPUTE TOTAL FLOW THROUGHOUT THE SYSTEM
C
      SYSFLO=0
      DO 47 J=1,11
   47 SYSFLO=SYSFLO+TOTFLO(J)
C
C  ACCUMULATE FLOW FROM SEGMENT TO SEGMENT THROUGH THE SYSTEM
C
      CUMNOD(12)=0.00
      TOTFLO(12)=0.00
      TOTFLO(11)=2137380.00
   58 READ(5,59)ISN,IN,NF,NPIPE1,NPIPE2,NPIPE3,NPIPE4,NPIPE5,NPIPE6,NODN
     *O1,NODNO2,NODNO3
   59 FORMAT(12I5)
      CUMPIP(IN)=TOTFLO(NPIPE1)+TOTFLO(NPIPE2)+TOTFLO(NPIPE3)+TOTFLO(NPI
     *PE4)+TOTFLO(NPIPE5)+TOTFLO(NPIPE6)
      CUMNOD(NF)=CUMPIP(IN)+CUMNOD(NODNO1)+CUMNOD(NODNO2)+CUMNOD(NODNO3)
      IF(ISN.LT.11)GO TO 58
      READ(5,60)MALCAP
   60 FORMAT(I1)
      IF(MALCAP)62,61,62
   61 CALL CAPCTY(CAP)
```

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```
      IF(MALCAP.EQ.0)GO TO 1080                                       47
   62 READ(5,63)CAP                                                   48
   63 FORMAT(6F11.2)                                                  49
C                                                                     49A
C     STATEMENTS FOR ALTCAP SUBROUTINE TO MODIFY FLOW FOLLOW          49B
C                                                                     49C
 1080 READ(5,64)NEWCAP                                                49D
   64 FORMAT(I1)                                                      49E
      IF(NEWCAP)76,65,76                                              49F
   65 CALL ALTCAP(REVCAP,NUMNEW)                                      49G
      INEWCP=0                                                        49H
   66 READ(5,67)NUM                                                   49I
   67 FORMAT(I5)                                                      49J
      INEWCP=INEWCP+1                                                 49K
      CAP(NUM)=REVCAP(INEWCP)                                         49L
      IF(INEWCP.LT.NUMNEW) GO TO 66                                   49M
C                                                                     50
      READ(5,70)INUM                                                  50A
   70 FORMAT(16I5)                                                    50B
C                                                                     51
C  COMPUTE TOTAL CAPACITY OF SYSTEM                                   52
C                                                                     53
   76 TOTCAP=0                                                        54
      DO 77 M=1,11                                                    55
   77 TOTCAP=CAP(M)+TOTCAP                                            56
C                                                                     57
C  OUTPUT STATEMENTS AND COMPARISON OF PROJECTED FLOWS TO CAPACITY    58
C                                                                     59
      WRITE(6,78)                                                     60
   78 FORMAT(1X,'NORTHSIDE SANITARY SEWER SYSTEM MASTER PLAN'//)      61
      WRITE(6,79)                                                     62
   79 FORMAT(1X,'PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000'//)  63
      WRITE(6,80)                                                     64
   80 FORMAT(1X,'FLOW FACTORS FOR THE YEAR 2000 ARE SHOWN BELOW:'/)   65
      WRITE(6,90)                                                     66
   90 FORMAT(1X,'UNITS ARE GALLONS PER ACRE PER DAY (GPAD).'//)       67
      WRITE(6,100)                                                    68
  100 FORMAT(1X,1X,'SING FAM';2X,'MULTI-LO';2X,'MULTI-HI';2X,'COMM-LO',2  69
     *X,' COMM-HI',2X,'INDUSTRY',2X,'INSTITUT'/)                      70
C                                                                     71
      WRITE(6,120)FLO(1),FLO(2),FLO(3),FLO(4),FLO(5),FLO(6),FLO(7)    72
  120 FORMAT(1X,F7.1,4X,F7.1,4X,F7.1,2X,F7.1,3X,F7.1,2X,F7.1,3X,F7.1///)  73
      WRITE(6,130)                                                    74
  130 FORMAT(1X,'LAND USES ARE ASSIGNED NUMBER CODES AS FOLLOWS:'/)   75
      WRITE(6,135)                                                    76
  135 FORMAT(1X,'1=SINGLE FAMILY,2=MULTI-FAMILY LOW DENSITY,3=MULTI-FAMI  77
     *LY-HIGH DENSI-'/1X,'TY,4=COMMERCIAL-LOW DENSITY,5=COMMERCIAL-HIGH   78
     *DENSITY,6=INDUSTRIAL,'/1X,'7=INSTITUTIONAL'////)                79
      K=0                                                             80A
      L=0                                                             80B
      M=0                                                             80C
      N=0                                                             80D
```

```
      IS=0                                                        80E
      NDEF=0                                                      80F
      DO 229 J=1,11                                               81
      IF(NEWCAP.EQ.1)GO TO 148                                    81AAAA
      IF(J.EQ.INUM(J))GO TO 141                                   81AAA
      IF(J.NE.INUM(J))GO TO 143                                   81BBB
  141 READ(5,142)NWSLIP,NWSLOP,NWDIAM                             81CCC
  142 FORMAT(3I5)                                                 81DDD
  143 IS=IS+1                                                     81A
      WRITE(6,144)J                                               81AA
  144 FORMAT(1X,I4/)                                              81AB
      WRITE(6,145)MINSYS(IS)                                      81B
  145 FORMAT(1X,'MINISYSTEM',1X,A5)                               81C
      K=K+1                                                       82
      WRITE(6,150)PIPE(K)                                         83
  150 FORMAT(1X,'PIPE NOMENCLATURE',1X,A7//)                      84
      WRITE(6,160)                                                85
  160 FORMAT(1X,'LANDUSE CODE',2X,'ACREAGE',2X,'PROJECTED FLOW (GPD)'/)   86
      DO 166 I=1,7                                                87
      WRITE(6,165)I,ACRES(I,J),PROFLO(I,J)                        88
  165 FORMAT(1X,7X,I2,5X,F7.2,4X,F11.2//)                         89
  166 CONTINUE                                                    89A
      N=N+1                                                       90
      WRITE(6,170)TOTFLO(N)                                       91
  170 FORMAT(1X,2X,'TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SE   92
     *GMENT ABOVE IS'/1X,F12.2,'GPD.'//)                          93
      L=L+1                                                       94
      WRITE(6,180)CUMNOD(L)                                       95
  180 FORMAT(1X,2X,'ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS:',1X,F12.2/)   96
      M=M+1                                                       97
       WRITE(6,190)CAP(M)                                         98
  190 FORMAT(1X,2X,'THE CAPACITY (GPD) OF THE ABOVE PIPE IS:',1X,F12.2//   99
     *)                                                           99A
C                                                                 100
C  COMPARISON OF PROJECTED FLOW TO CAPACITY                       101
C                                                                 102
      DIFFLO(N)=CAP(M)-CUMNOD(L)                                  103
      IF (DIFFLO(N))200,212,212                                   104
  200 WRITE(6,201)DIFFLO(N)                                       105
  201 FORMAT(1X,'THE CAPACITY OF THE PIPE IS EXCEEDED BY-',F12.2,'--GALL   106
     *ONS PER DAY.'/////)                                         107
      IF(NEWCAP.EQ.1)GO TO 211                                    107AAA
      IF(J.EQ.INUM(J))GO TO 202                                   107BBB
      IF (J.NE.INUM(J))GO TO 211                                  107CCC
  202 IF(NWSLIP.EQ.1) GO TO 207                                   107AA
      WRITE(6,206)                                                107BB
  206 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLIPLINING."/////)   107CC
  207 IF(NWSLOP.EQ.1) GO TO 209                                   107DD
      WRITE(6,208)                                                107EE
  208 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLOPE ADJUSTMENT."/   107FF
     *////)                                                       107GG
  209 IF(NWDIAM.EQ.1) GO TO 211                                   107HH
```

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```
          WRITE(6,210)                                                          107II
      210 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY INCREASED DIAMETER.    107JJ
         *"//////)                                                              107KK
      211 NDEF=NDEF+1                                                           107A
          DEFICT(NDEF)=DIFFLO(N)                                                107B
          MINDEF(NDEF)=MINSYS(IS)                                               107C
          PIPDEF(NDEF)=PIPE(K)                                                  107D
          GO TO 225                                                             108
      212 WRITE(6,215)DIFFLO(N)                                                 109
      215 FORMAT(1X,'THIS PIPE IS ADEQUATE BY',1X,F12,2,1X,'GPD,'/////)        110
          IF(NEWCAP,EQ,1)GO TO 225                                              110A
          IF(J,EQ,INUM(J))GO TO 216                                             110B
          IF (J,NE,INUM(J))GO TO 225                                            110C
      216 IF(NWSLIP,EQ,1) GO TO 219                                             110F
          WRITE(6,218)                                                          110G
      218 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLIPLINING."/////)    110H
      219 IF(NWSLOP,EQ,1) GO TO 221                                             110I
          WRITE(6,220)                                                          110J
      220 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY SLOPE ADJUSTMENT."/   110K
         *////)                                                                 110L
      221 IF(NWDIAM,EQ,1) GO TO 225                                             110M
          WRITE(6,222)                                                          110N
      222 FORMAT(1X,"CAPACITY OF ABOVE PIPE INCREASED BY INCREASED DIAMETER.    110O
         *"//////)                                                              110P
      225 CONTINUE                                                              111
          WRITE(6,230)SYSFLO                                                    112
      230 FORMAT(1X,'THE TOTAL PROJECTED FLOW THROUGHOUT THE SYSTEM IS',1X,    113
         *F12,2,1X,'GALLONS',/,1X,'PER DAY.'/)                                  114
          WRITE(6,240)TOTCAP                                                    115
      240 FORMAT(1X,'THE TOTAL CAPACITY OF THE SYSTEM IS',1X,F12.2,1X,'GALLO   116
         *NS',/1X,'PER DAY,'///)                                                117
          IF(DEFICT(1))250,355,359                                              118
      250 WRITE(6,252)                                                          119
      252 FORMAT(1X,'A LISTING OF PIPES WITH INADEQUATE CAPACITY TO HANDLE P   120
         *ROJECTED AC-'/1X,'CUMULATED FLOW FOLLOWS.  THE MINIMUM SIZE PARALL   121
         *EL PIPE REQUIRED TO RE-'/1X,'LIEVE EXCESS FLOW IS REFLECTED IN THE   122
         * FOURTH COLUMN BELOW.  THIS PIPE  '/1X,'SIZE IS OBTAINED FROM MANN   123
         *ING S EQUATION WITH N=,013 AND SLOPE=STAN-'/1X,'DARD GRADE AS SPEC   124
         *IFIED IN THE ADDENDUM TO E-14, CITY OF HOUSTON SPECI-'/1X,'FICATI    125
         *ON FOR SEWER CONSTRUCTION-PAGE 4,'///)                                125AA
          WRITE(6,254)                                                          125A
      254 FORMAT(1X,'MINISYSTEM',5X,'PIPE NOMENCLATURE',5X,'DEFICIENCY(GPD)'   126
         *,5X,'MIN RELIEF SIZE(IN)'///)                                         127
          DO 350 I=1,NDEF                                                       128
          IF(DEFICT(I),LT,-1080000)GO TO 255                                    129
          RELIEF(I)=12,0                                                        130
          GO TO 340                                                             131
      255 IF(DEFICT(I),LT,-1617000)GO TO 260                                    132
          RELIEF(I)=15,0                                                        133
          GO TO 340                                                             134
      260 IF(DEFICT(I),LT,-2352000)GO TO 265                                    135
          RELIEF(I)=18,0                                                        136
```

```
      GC TO 340                                              137
  265 IF(DEFICT(I).LT.-4135000)GO TO 270                     138
      RELIEF(I)=24.0                                         139
      GC TO 340                                              140
  270 IF(DEFICT(I).LT.-5661000)GC TO 273                     140A
      RELIEF(I)=27.0                                         140B
      GC TO 340                                              140C
  273 IF(DEFICT(I).LT.-7498000)GO TO 275                     141
      RELIEF(I)=30.0                                         142
      GC TO 340                                              143
  275 IF(DEFICT(I).LT.-12192000)GO TO 280                    144
      RELIEF(I)=36.0                                         145
      GC TO 340                                              146
  280 IF(DEFICT(I).LT.-18391000)GO TO 285                    147
      RELIEF(I)=42.0                                         148
      GO TO 340                                              149
  285 IF(DEFICT(I).LT.-26257000)GO TO 287                    149A
      RELIEF(I)=48.0                                         149B
      GO TO 340                                              149C
  287 IF(DEFICT(I).LT.-35946000)GO TO 290                    150
      RELIEF(I)=54.0                                         151
      GC TO 340                                              152
  290 IF(DEFICT(I).LT.-37636000)GO TO 295                    153
      RELIEF(I)=60.0                                         154
      GO TO 340                                              155
  295 IF(DEFICT(I).LT.-54739000)GO TO 300                    156
      RELIEF(I)=72.0                                         157
      GC TO 340                                              158
  300 IF(DEFICT(I).LT.-58385000)GO TO 305                    159
      RELIEF(I)=84.0                                         160
      GC TO 340                                              161
  305 IF(DEFICT(I).LT.-70178000)GO TO 310                    162
      RELIEF(I)=90.0                                         163
      GC TO 340                                              164
  310 IF(DEFICT(I).LT.-114116000)GO TO 315                   165
      RELIEF(I)=108.0                                        166
      GC TO 340                                              167
  315 IF(DEFICT(I).LT.-151184000)GO TO 320                   168
      RELIEF(I)=120.0                                        169
      GC TO 340                                              170
  320 IF(DEFICT(I).LT.-198868000)GO TO 325                   171
      RELIEF(I)=132.0                                        172
      GC TO 340                                              173
  325 IF(DEFICT(I).LT.-245758000)GO TO 330                   174
  330 RELIEF(I)=144.0                                        175
      GC TO 340                                              176
  340 WRITE(6,345)MINDEF(I),PIPDEF(I),DEFICT(I),RELIEF(I)    177
  345 FORMAT(1X,2X,A5,11X,A7,12X,F12.2,17X,F5.1///)          178
  350 CONTINUE                                               179
      GC TO 365                                              180
  355 WRITE(6,360)                                           181
  360 FCRMAT(1X,'ALL PIPES EVALUATED IN THE ABOVE NETWORK ARE ADEQUATE T   182
```

```
    261            *O HANDLE PRO-'/1X,'JECTED ACCUMULATED FLOW.'///)      183
                                                                         184
    262        305 STOP                                                  185
    263            END
******W     7 MEMORY EXPANDED, USE SLIMITS OR CORE= OPTION FOR NEXT RUN
```

AD-A106 373   AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH   F/G 13/2
INTERN EXPERIENCE WITH TURNER COLLIE AND BRADEN INC. AN INTERNS--ETC(U)
AUG 79   D R TOPPER
UNCLASSIFIED   AFIT-CI-79-219D   NL

6 OF 6
AD
A106 373

END
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```
      SUBROUTINE CAPCTY(CAP)                                              133A
      DIMENSION CAP(10),AREA(10),WETPER(10),HYRAD(10),R(10),S(10),DIAM(1  134
     *0),SLOPE(10),ROUGHN(10),VEL1(10),VEL2(10),VELCTY(10),CFS(10)        135
      READ(5,300)DIAM                                                     136
  300 FORMAT(14F5.1)                                                      137
      READ(5,310)ROUGHN                                                   138
  310 FORMAT(14F5.3)                                                      139
      READ(5,320)SLOPE                                                    140
  320 FORMAT(12F6.4)                                                      141
      PIE=3.1459                                                          142
      DO 340 M=1,10                                                       143
      AREA(M)=((PIE*(DIAM(M)**2))/4.00)/144.00                            144
      WETPER(M)=PIE*DIAM(M)/12.00                                         145
      HYRAD(M)=AREA(M)/WETPER(M)                                          146
      R(M)=HYRAD(M)**.6666667                                             147
      S(M)=SLOPE(M)**.5                                                   148
      VEL1(M)=1.486/ROUGHN(M)                                             149
      VEL2(M)=R(M)*S(M)                                                   150
      VELCTY(M)=VEL1(M)*VEL2(M)                                           151
      CFS(M)=AREA(M)*VELCTY(M)                                            152
      CAP(M)=CFS(M)*7.48*86400.00                                         152A
  340 CONTINUE                                                            153
      RETURN                                                              154
      END                                                                 155
```

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```
      SUBROUTINE ALTCAP(REVCAP,NUMNEW)                                    156
      DIMENSION REVCAP(1),AREA(1),WETPER(1),HYRAD(1),R(1),S(1),DIAM(1),S  157
     *LOPE(1),ROUGHN(1),VEL1(1),VEL2(1),VELCTY(1),CFS(1),ORICAP(1)        158
      READ(5,400)NUMNEW                                                   159
  400 FORMAT(I5)                                                          160
      READ(5,410)DIAM                                                     161
  410 FORMAT(14F5.1)                                                      162
      READ(5,420)ROUGHN                                                   163
  420 FORMAT(14F5.3)                                                      164
      READ(5,430)SLOPE                                                    165
  430 FORMAT(12F6.4)                                                      166
      READ(5,435)ORICAP                                                   166A
  435 FORMAT(6F12.2)                                                      166B
      PIE=3.1459                                                          167
      DO 440 N=1,NUMNEW                                                   168
      AREA(N)=((PIE*(DIAM(N)**2))/4.00)/144.00                            169
      WETPER(N)=PIE*DIAM(N)/12.00                                         170
      HYRAD(N)=AREA(N)/WETPER(N)                                          171
      R(N)=HYRAD(N)**.6666667                                             172
      S(N)=SLOPE(N)**.5                                                   173
      VEL1(N)=1.486/ROUGHN(N)                                             174
      VEL2(N)=R(N)*S(N)                                                   175
      VELCTY(N)=VEL1(N)*VEL2(N)                                           176
      CFS(N)=AREA(N)*VELCTY(N)                                            177
      REVCAP(N)=(CFS(N)*7.48*86400)+ORICAP(N)                             178
  440 CONTINUE                                                            179
      RETURN                                                              180
      END                                                                 181
```

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```
SNUMB = R1007, ACTIVITY # = 02, , REPORT CODE = 06, RECORD COUNT = 000382
NORTHSIDE SANITARY SEWER SYSTEM MASTER PLAN

PROGRAM TO COMPUTE PROJECTED SEWAGE FLOWS-YEAR 2000

FLOW FACTORS FOR THE YEAR 2000 ARE SHOWN BELOW:
UNITS ARE GALLONS PER ACRE PER DAY (GPAD).

 SING FAM  MULTI-LO  MULTI-HI  COMM-LO   COMM-HI  INDUSTRY  INSTITUT
 6000.0    15000.0    20000.0   6000.0   15000.0   6000.0    6000.0


LAND USES ARE ASSIGNED NUMBER CODES AS FOLLOWS:
1=SINGLE FAMILY,2=MULTI-FAMILY LOW DENSITY,3=MULTI-FAMILY-HIGH DENSI-
TY,4=COMMERCIAL-LOW DENSITY,5=COMMERCIAL-HIGH DENSITY,6=INDUSTRIAL,
7=INSTITUTIONAL


 1
MINISYSTEM    C2
PIPE NOMENCLATURE  N1EEB1

LANDUSE CODE  ACREAGE  PROJECTED FLOW (GPD)
        1       70.45       422700.00

        2        0.            0.

        3        5.20      104000.00

        4       24.68      148080.00

        5        0.            0.

        6        0.            0.

        7        2.09       12540.00

  TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
   687320.00GPD.

  ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS:    687320.00
  THE CAPACITY (GPD) OF THE ABOVE PIPE IS:    860000.00

THIS PIPE IS ADEQUATE BY    172680.00 GPD.



 2
MINISYSTEM   C15
PIPE NOMENCLATURE  N1EEBA

LANDUSE CODE  ACREAGE  PROJECTED FLOW (GPD)
        1      148.46      890759.99

        2        0.            0.

        3       23.45      469000.00
```

4	6,97	41820.00
5	0.	0.
6	0.	0.
7	8,08	48480.00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
1450060.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 1450060.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 680000.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -770060.00--GALLONS PER DAY.

3
MINISYSTEM C41
PIPE NOMENCLATURE N1EEA1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	145,25	871500,00
2	3,84	45800,00
3	86,21	1724200,00
4	19,01	114060,00
5	0,	0,
6	27,39	164340,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
2919700,00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 2919700,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1430000,00

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -1489700.00--GALLONS PER DAY.

4
MINISYSTEM C16
PIPE NOMENCLATURE N1FEB

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	5,49	32940,00
2	0,	0,
3	7,92	158400,00

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4	21,29	127740,00
5	0,	0,
6	3,05	18300,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
- >337380.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 337380.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1600000.00

THIS PIPE IS ADEQUATE BY 1262620,00 GPD,

5
MINISYSTEM C17
PIPE NOMENCLATURE N1EE

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	236,68	1420080,00
2	0,	0,
3	17,85	357000,00
4	50,03	300180,00
5	0,	0,
6	12,89	77340,00
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
2154600.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 5411680.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 5604884.94

THIS PIPE IS ADEQUATE BY 193204,94 GPD,

CAPACITY OF ABOVE PIPE INCREASED BY INCREASED DIAMETER,

6
MINISYSTEM C1
PIPE NOMENCLATURE N10082

LANDUSE CODE ACREAGE PROJECTED FLOW (GPD)

1	70,28	421680.00
2	3,84	57600.00
3	7,29	145800.00
4	18,17	109020.00
5	0,	0.
6	0,	0.
7	0,	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
733380.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 733380.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 860080.00

THIS PIPE IS ADEQUATE BY 126700.00 GPD.

7
MINISYSTEM C3
PIPE NOMENCLATURE N1DDB1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	138,77	832620.00
2	0,	0.
3	3,19	63800.00
4	0,	0.
5	0,	0.
6	0,	0.
7	0,	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
896420.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 1629720.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1310080.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -319720.00--GALLONS PER DAY.

8
MINISYSTEM C4
PIPE NOMENCLATURE N1DDB

LANDUSE CODE ACREAGE PROJECTED FLOW (GPD)

1	218.04	1308240.00
2	3.26	48900.00
3	13.87	277400.00
4	8.25	49500.00
5	6.20	93000.00
6	10.97	65820.00
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
3042860.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 3472580.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1800000.00

THE CAPACITY OF THE PIPE IS EXCEEDED BY- -1672580.00--GALLONS PER DAY.

9
MINISYSTEM C18
PIPE NOMENCLATURE N1DD

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	5.02	30120.00
2	0.	0.
3	8.29	165800.00
4	34.42	206520.00
5	0.	0.
6	23.25	139500.00
7	23.37	140220.00

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVF IS
682160.00GPD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 4154740.00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 5100000.00

THIS PIPE IS ADEQUATE BY 945260.00 GPD.

10
MINISYSTEM C42
PIPE NOMENCLATURE N1DDA

LANDUSE CODE ACREAGE PROJECTED FLOW (GPD)

1	76.34	458040.00
2	0.	0.
3	0.	0.
4	46.12	276720.00
5	0.	0.
6	0.	0.
7	0.	0.

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
734760.000PD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 734760,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 1310000,00

THIS PIPE IS ADEQUATE BY 575240,00 GPD,

MINISYSTEM C63
PIPE NOMENCLATURE DUMMY1

LANDUSE CODE	ACREAGE	PROJECTED FLOW (GPD)
1	0,	0,
2	0,	0,
3	0,	0,
4	0,	0,
5	0,	0,
6	0,	0,
7	0,	0,

TOTAL FLOW FROM THIS MINISYSTEM ALONE TO THE PIPE SEGMENT ABOVE IS
2137380.000PD.

ACCUMULATED FLOW (GPD) OF ABOVE PIPE IS: 2137380,00
THE CAPACITY (GPD) OF THE ABOVE PIPE IS: 2352000,00

THIS PIPE IS ADEQUATE BY 214620,00 GPD,

THE TOTAL PROJECTED FLOW THROUGHOUT THE SYSTEM IS 12438560,00 GALLONS
PER DAY.
THE TOTAL CAPACITY OF THE SYSTEM IS 22906885,00 GALLONS
PER DAY.

A LISTING OF PIPES WITH INADEQUATE CAPACITY TO HANDLE PROJECTED ACCUMULATED FLOW FOLLOWS. THE MINIMUM SIZE PARALLEL PIPE REQUIRED TO RELIEVE EXCESS FLOW IS REFLECTED IN THE FOURTH COLUMN BELOW. THIS PIPE SIZE IS OBTAINED FROM MANNING S EQUATION WITH N=.013 AND SLOPE=STANDARD GRADE AS SPECIFIED IN THE ADDENDUM TO E-14, CITY OF HOUSTON SPECIFICATI ON FOR SEWER CONSTRUCTION-PAGE 4,

MINISYSTEM	PIPE NOMENCLATURE	DEFICIENCY(GPD)	MIN RELIEF SIZE(IN)
C15	N1EEBA	-770060.00	12.0
C41	N1EEA1	-1489700.00	15.0
C8	N1DDB1	-319720.00	12.0
C8	N1DDB	-1672980.00	18.0

APPENDIX E - CODING FORM WORKSHEETS


FILME
2